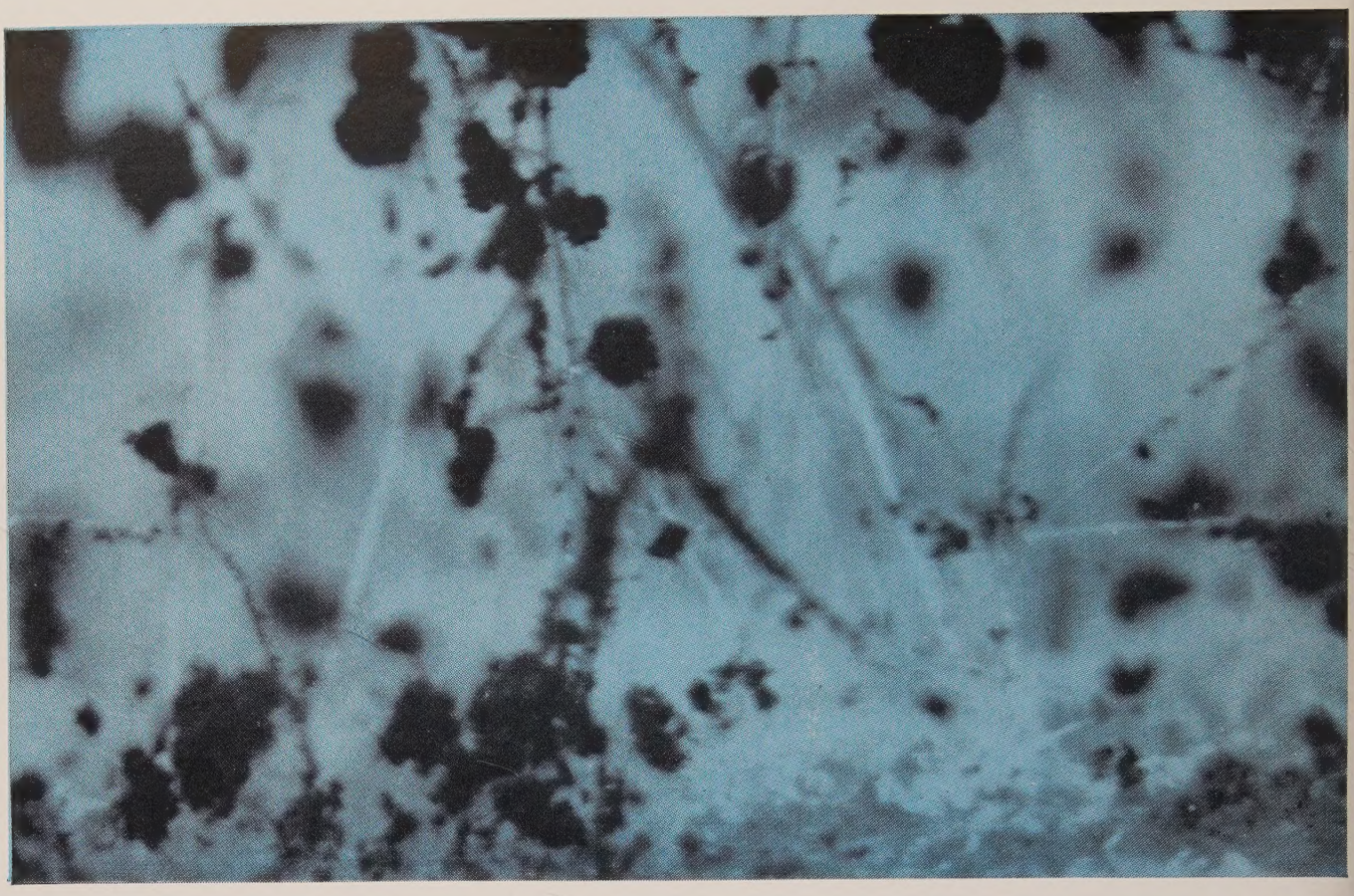
Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JUNE 1949



An example of Aspergillus Niger—a common discoloring mold magnified seventy times.

stop feeding your profits to fungi!

How much profit are you losing to mold and bacterial attack? These microorganisms cause countless losses from mildew on lap stock in storage, from deterioration of paperboard cartons in humid warehouses, deterioration of machine felt and dry rot in pulp wood.

Now you can effectively control such losses with Dowicides, Dow's industrial germicides and fungicides. Dowicides are recognized throughout the pulp and paper industry as the best protection against mildew and rot during practically all of the manufacturing processes . . . from raw wood to the finished product. For instance, starches, casein, glue and other decomposable adhesives can now be made mold-resistant with Dowicides.

Investigate Dowicides now. Protect your profits from fungi! Complete laboratory facilities are maintained by Dow to help you solve your problems. Just contact your nearest Dow office or write direct to Midland.

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TO INDUSTRY AND AGRICULTURE

West Virginia: kraft paper and board

At Charleston, South Carolina, this mill of the West Virginia Pulp and Paper Company makes top quality kraft paper and board in a wide variety of weights. A new Beloit High Speed Kraft Fourdrinier machine, the mill's number two, was started recently and, according to company statements, is successfully carrying its share of the load. And Beloit additions on number one machine are helping materially to cut operating costs. Various items of Beloit equipment are used in each of this company's six mills.—*Beloit Iron Works, Beloit, Wis.*

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BELOIT IRON WORKS · PAPER MACHINERY · BELOIT, WIS., U.S.A.

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PAPER MACHINERY

for boxboard and wrapping papers

Calco

METHYLENE BLUE 2B CONC.

A clear, greenish basic blue, METHYLENE BLUE 2B CONC. has good solubility and performs well in all types of coloring—beater, calender and coating.

In addition to its extensive use in boxboard and wrapping papers, METHYLENE BLUE 2B CONC. produces shades varying from light blues and grays to deep and medium blues on kraft, tissue, boxboard and poster paper. Used in conjunction with METHYL VIOLET 4 PBX CONC., and GREEN MX CONC., it produces light and deep blues and violets. It is applied to both sized and unsized papers, and when treated with tannic acid, its light fastness is much improved.

Have you a problem about the application of color to paper? Consult your Calco representative. He will be glad to assist you and make recommendations from Calco's wide range of paper colors.

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ETERNAL VIGILANCE

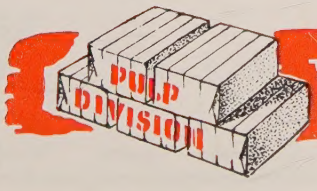
Weyerhaeuser is in the business of growing trees . . . looking ahead to a continuous, never-ending supply of timber.

That is the reason a forest fire today is seen as more than an immediate loss. It is recognized also as a threat to the future well being not only of Weyerhaeuser and the Pacific Northwest but of other communities, and even the nation at large.

And that is why in cooperation with others in industry and government, Weyerhaeuser helps maintain a vast network of look-out towers, forest patrols, radio and telephone communications, tank trucks and roads. Trained fire-fighters are always available. Forest fire prevention today and tomorrow is in the public interest for the present and the future.

YES! GO WEST!

1949 Fall Meeting TAPPI Portland, Oregon



WEYERHAEUSER

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installed or contracted for by Pulp & Paper Mills during the past two years include

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JUNE 1949

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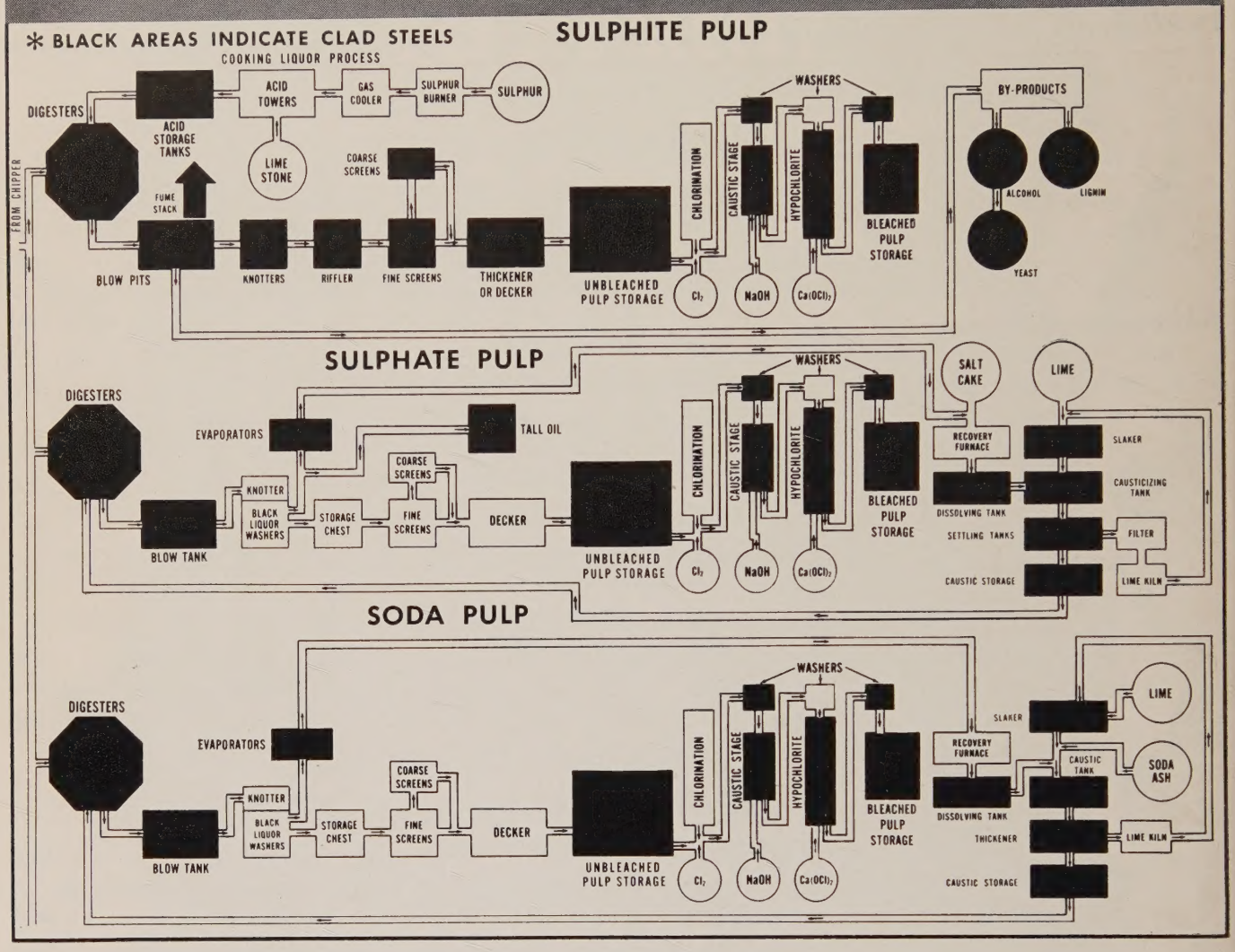
Applications for *Clad Steels** in Paper-Pulp Making



Lukens Clad Steels—Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad—are serving at many locations in the Pulp and Paper Industry, providing *solid* corrosion-resistant metal protection at the lower cost of *clad* steels. Your suppliers of processing equipment are familiar with their advantages. Many companies have standardized on Lukens Clad Steels wherever they have encountered trouble with corrosion.

The new Bulletin 470, "Product and Equipment Protection for the Pulp and Paper Industry", is just off the press. For a copy and for help on your corrosion problems, write Lukens Steel Company, 501 Lukens Building, Coatesville, Pennsylvania.

LUKENS

Nickel-Clad Stainless-Clad
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STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

VORTRAP

Naturally—Vortraps were chosen

In mill after mill, for CLEAN pulp and paper you'll note the choice is—Vortraps. Popularity earned by outstanding service. Yesterday—today and tomorrow—it's Vortraps.

It is a fact that Vortraps are used in greater numbers and in more mills throughout the world than all other types of centrifugal stock cleaning equipment.

The Nichols Freeman Vortrap installation in the Weyerhaeuser Timber Company's new Kraft Pulp Mill, Longview, Washington, illustrates the simplicity of design and layout possible with Vortraps. It is to be noted that only the basic, necessary equipment for the production of clean, high grade pulp is employed.

Vortraps are engineered and sold only by the Nichols Engineering & Research Corp. and its accredited sales representatives. Write for Bulletin No. 219-B.

NICHOLS

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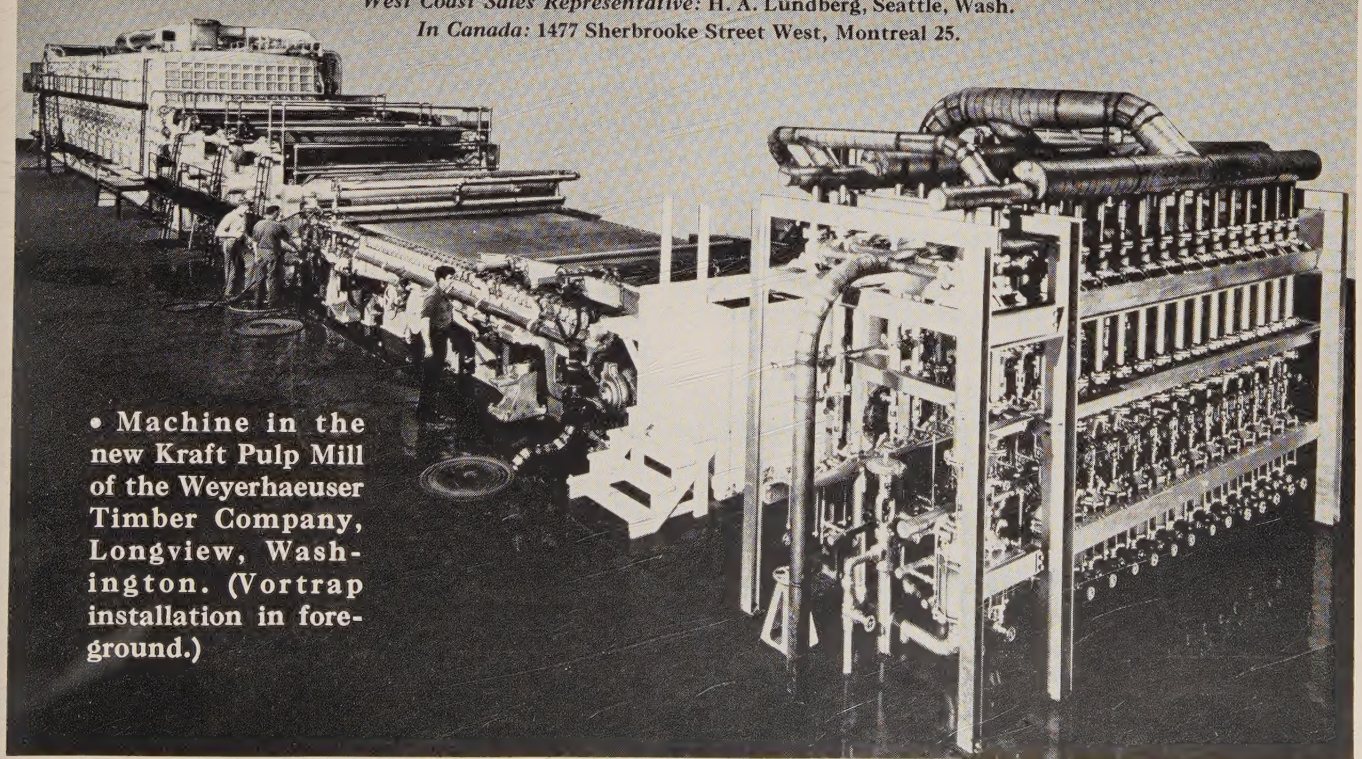


• Machine in the new Kraft Pulp Mill of the Weyerhaeuser Timber Company, Longview, Washington. (Vortrap installation in foreground.)

PRETTY MUCH "OLD HAT"

A new hat that fits pretty much like the old one would be the millennium.

It may not happen "once in a blue moon," but it did happen last year to Sonoco Products Co., Hartsville, S. C.

Sonoco's new Downingtown Fourdrinier produced saleable paper on the first roll and has been in successful operation ever since. This performance, while unusual, didn't "just happen." Downingtown engineers have spent years in the development of a fourdrinier section, with many "never-tried-before" labor saving, smooth running features. For instance, Sonoco's wire is replaced in 40 minutes and lasts about 40 days.

Today's competitive market demands quality paper. You can't afford to slow down your machines to improve quality, especially if your mill's "break even" point is little below your top operating speed. Profits lie in greater production or improved quality or both, with fewer breaks in the sheet and, therefore, less "broke." That's where Downingtown can help you, whether you want a new fourdrinier section or press part, or your old ones modernized.

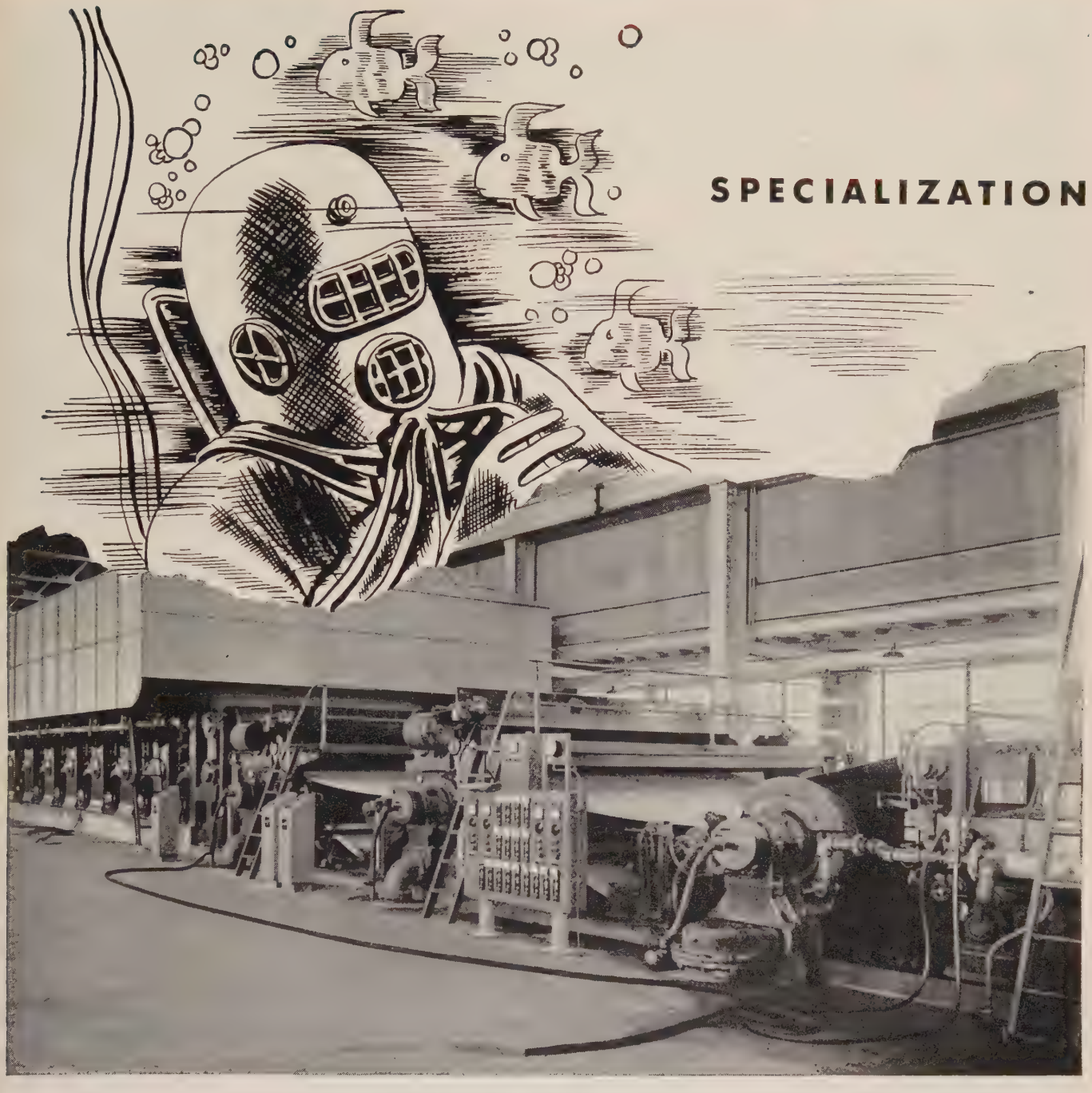
If you'd like the "complete story" about Sonoco's Downingtown Machine, one of our engineers will call whenever you say. Write, wire or phone us.

DOWNINGTOWN MANUFACTURING COMPANY

DOWNINGTOWN, PA.

DESIGNERS AND BUILDERS OF PAPER MAKING MACHINERY SINCE 1880

-17-960



SPECIALIZATION

It takes a special brand of skill to bring a "gem of purest ray serene" up from the "dark uncharted caverns" of ocean floor. *Specialization.*

It takes a special brand of skill to weigh a papermaker's problem, conceive the solution and translate that solution into iron and steel. *Again, it's specialization.*

For seventy-six years Black-Clawson has been specializing—studying the techniques of papermaking, developing equipment better to serve the industry.

CYLINDER MACHINES AND FOURDRINIERS. All sizes, all speeds. Latest features, including "HYDRONAMIC" Inlets. DRIVES, CALENDERS, REELS, WINDERS, CUTTERS.

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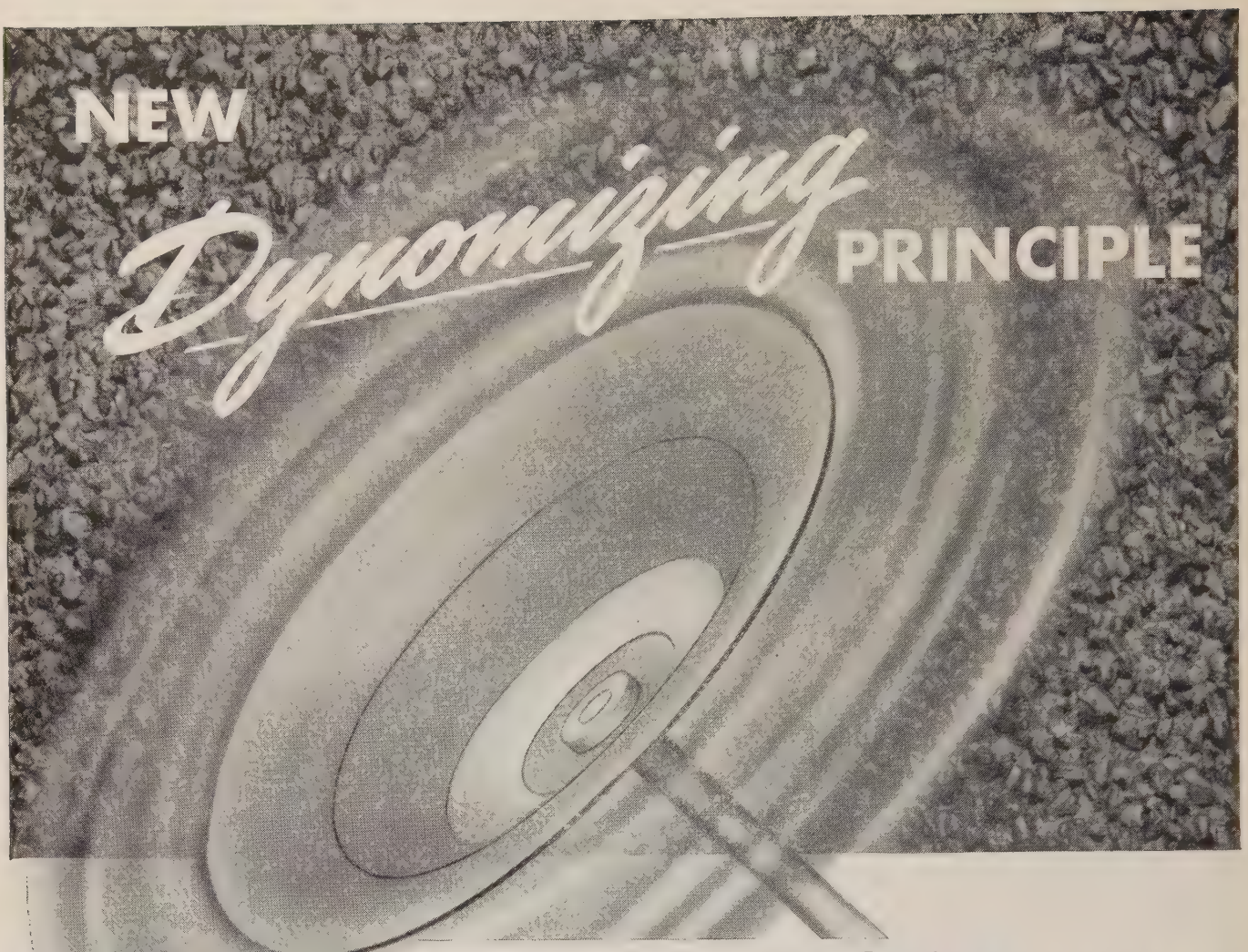

—completely disintegrates any type of paper stock

The pulp or waste paper to be processed is hydraulically drawn into the center of the concave surface of the DynoPeller. The periphery of the DynoPeller is lined with numerous rough pieces of hardened tungsten carbide. Centrifugal force forces the stock over this roughened surface where the dynomizing action takes place in the treatment of the stock.

The stock is completely disintegrated—being reduced to its original fibre length—each individual fibre being completely separated from its neighbor.

Send for additional information.

The DynoPulper

is equipped with two DynoPellers and is primarily used in a batch operation. A bale may be charged at one time. This machine is also available in laboratory size.

The QuatroPulper

is also primarily used in batch operations. It is equipped with four DynoPellers and will handle large volumes.

The DynoChest

is equipped with one DynoPeller and will process broke or slush stock. It is used as a storage chest while completing the defiberization of stock.

The DynoFiner

is equipped with either four or six small DynoPellers. It is used in a continuous operation and completely separates fibre bundles from slush stock.

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2 WORLD'S LARGEST SINGLE-UNIT SULPHURIC ACID PLANTS...

With the acquisition of Standard Wholesale Acid and Phosphate Works, and Southern Acid & Sulphur Company, Inc., Mathieson now operates the *two largest single-unit sulphuric acid plants in the world* . . . adds *another* basic product to its growing list of industrial chemicals.

With other strategically located producing units, these plants form a network of supply centers which enables Mathieson to provide an even greater service to the chemical consuming industries. Mathieson Chemical Corporation, 60 East 42nd Street, New York 17, N. Y.

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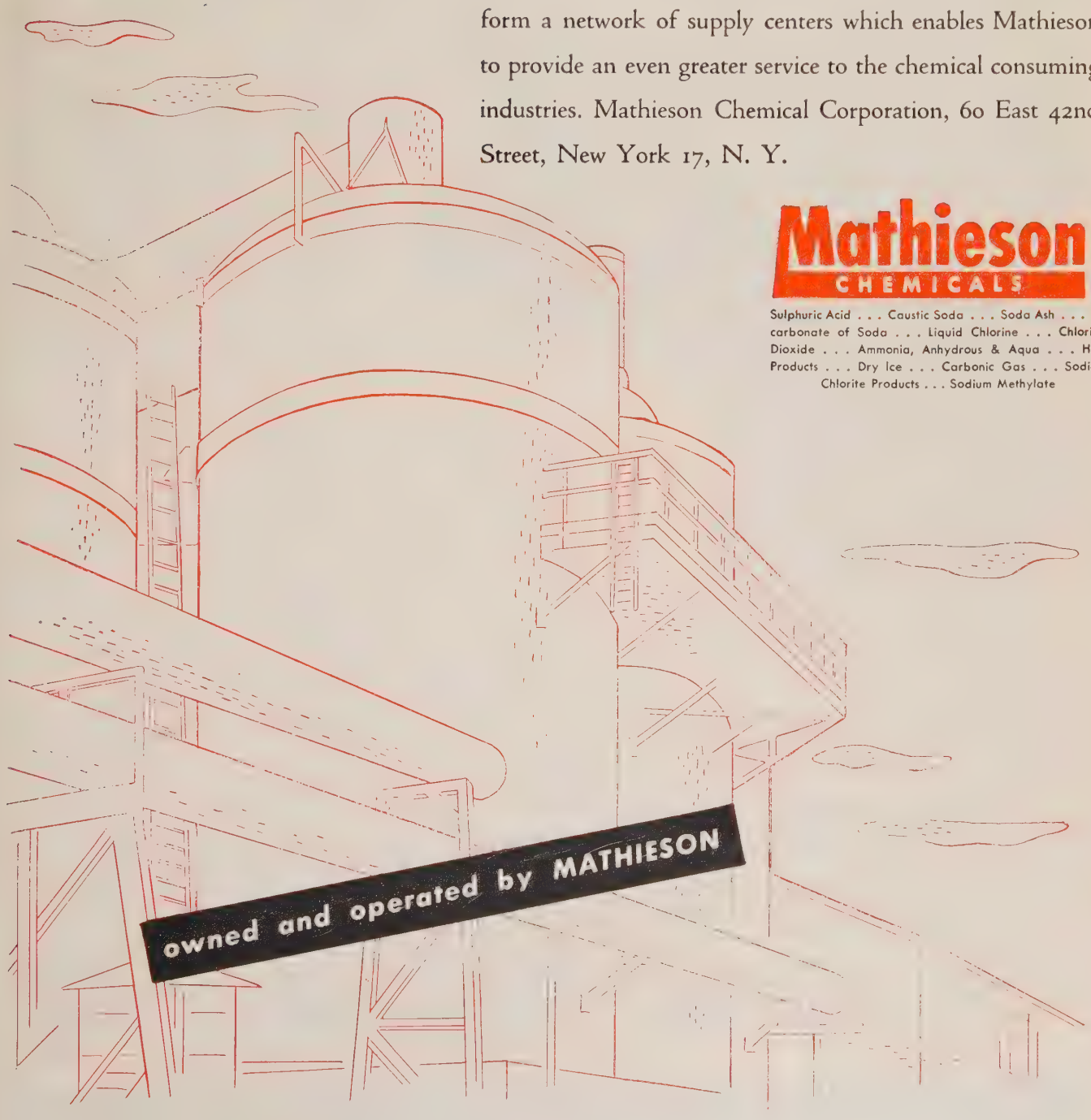
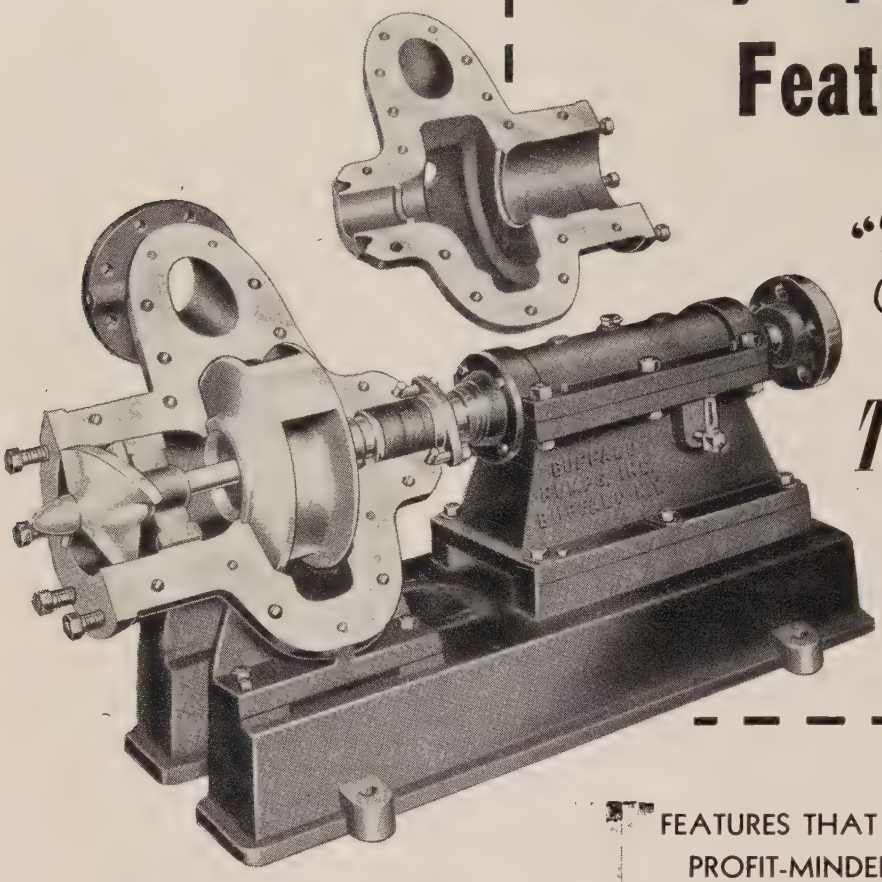


Many Special Features in this "Buffalo" PUMP

To get your costs DOWN!



FEATURES THAT HAVE BEEN APPROVED BY PROFIT-MINDED OPERATORS FOR YEARS

● A good way to improve the profit picture in your mill is to start with the pumps. Are they "eating up the earnings" by wasting power—by keeping the maintenance crew busy—by causing frequent timeouts?

The "Buffalo" Diagonally Splitshell Pump above is one of a full line of stock pumps that ARE saving money for operators. They're making every kilowatt move MAXIMUM stock through their high efficiencies. They're taking all the shock and punishment of mill service with minimum attention. And most important, they're not stopping a process which is your "bread and butter." There's a "Buffalo" Pump to cut costs on any stock you handle.

● **NON-CLOGGING IMPELLER**
Does not depend on close tolerances for its high efficiencies—free from wear and "wedging", too.

● **DIAGONALLY SPLIT SHELL ACCESSIBILITY**—upper half of pump casing easily removed for inspection, as shown, without disturbing piping.

● **RUGGED CONSTRUCTION** — all parts solidly, heavily built. Over-size shafts to stand shock, stuffing boxes extra deep.

● **LASTING EFFICIENCY** because of the enclosed impellers and absence of close tolerances.

Write for Bulletin 953-F for all the engineering facts on more efficient stock pumping. And call in your "Buffalo" representative for sound, helpful advice on your particular problem.

YES! GO WEST!
1949 Fall Meeting TAPPI
Portland, Oregon

"Buffalo" PUMPS

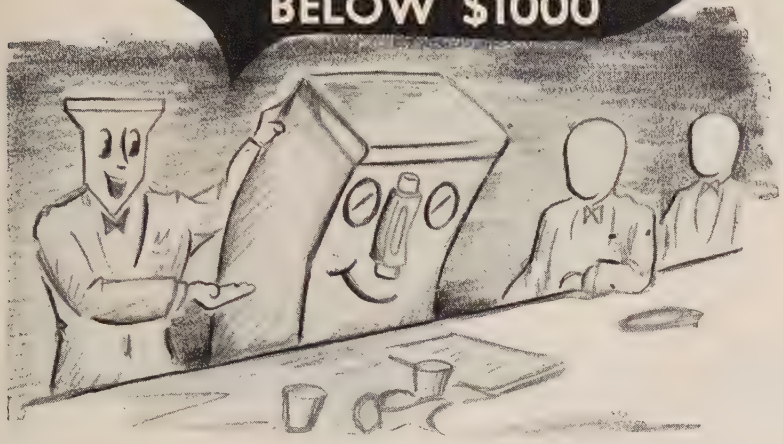
BUFFALO PUMPS INC.

528 BROADWAY BUFFALO, NEW YORK

Canada Pumps Ltd., Kitchener, Ont.

A BETTER CENTRIFUGAL PUMP FOR EVERY LIQUID

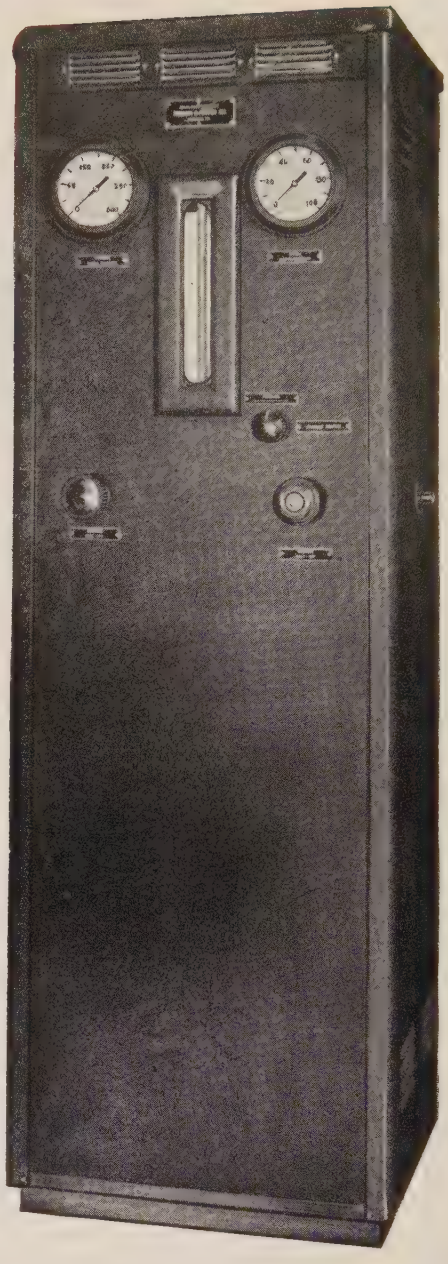
INTRODUCING RATO-CHLOR: A REVOLUTIONARY CHLORINATOR PRICED BELOW $1000



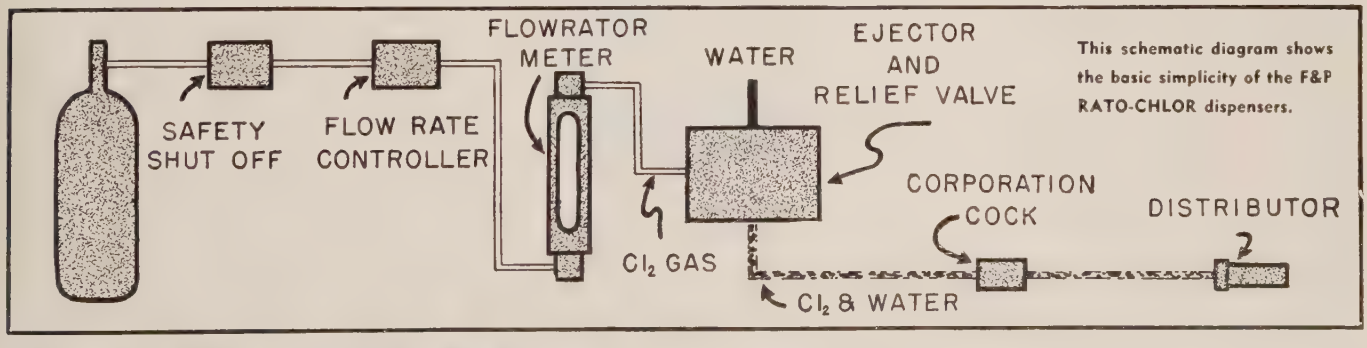
New in every sense of the word . . . No poppet valves, no bell jars, no water seals . . . just an assembly of standard instruments! It's simple—it's inexpensive—it's versatile—it's accurate—it's compact. Maintenance costs are negligible.

Three standard models cover every chlorine requirement—municipal, industrial, or swimming pool. Prices start at $300. Solution feed, dry gas feed, or hypochlorite for flow rates as low as 5 lbs. per day.

Be sure to get your copy of Catalog 61 which contains an illustrated description of RATO-CHLOR dispensers now used in more than 100 installations.



Model S-1000 RATO-CHLOR Dispenser



This schematic diagram shows the basic simplicity of the F&P RATO-CHLOR dispensers.

FLOWRATOR TRADE MARK

FISCHER & PORTER COMPANY

DEPT. 9R-7P HATBORO, PA.

INSTRUMENTS FOR FLOW RATE MEASUREMENT AND AUTOMATIC FLOW CONTROL

EDITORIAL *Tappi* COMMENT

The Institute at Twenty

In May the Institute of Paper Chemistry celebrated its twentieth anniversary. The cavalcade of its progress, as presented by members of the staff, was a revelation of a good job, well done. For all of us a span of a double-decade is a period that seems to creep up. It is, in retrospect, that the magnitude of stewardship is accounted for. Beginning in 1929 with a teaching staff consisting of Otto Kress and a student body consisting of Harold Bialkowsky, now a member of the TAPPI Executive Committee and Roy Davis the following years have produced a record for which the Institute and the industry can be proud.

Over this period 152 individuals graduated with either master or doctorate degrees. A library of 13,000 volumes has been accumulated. An annual operating budget advanced from $40,000 to $850,000, and so on.

The main objectives of the Institute have been to educate technical men for the industry, to perform useful research, and to accumulate a library. These ends have been meritoriously attained—and at twenty the great Fox River Valley institution has merely reached the so-called age of maturity. It has survived conditions that tried mens souls and can face the future with a know-how that promises accomplishment of a sustained high order.

Employment

Having instituted an employment service in *Tappi* it is interesting to note the results obtained in connection with the items run in the last two issues. Although most of the responses have been received from individuals seeking employment there has been a goodly number of inquiries from employers. The employment situation has always been a good barometer of industry jitters of various kinds.

The Association has always been extremely sensitive to the vocational welfare of its members. An inquiry for a position, particularly if a member is unemployed has always received immediate attention and a continued effort has been made to get the applicant back in a job. There has seldom been a period of balance. During the past few years there have been more jobs than men and during the thirties, there was, of course, the heartbreaking long list of applicants and relatively few jobs available.

Come what may in the near future it is evident that the stability of jobs of TAPPImen will be greater than during the depression years since a much larger number now hold positions as supervisors and managers and are not as expendible as the young engineer and chemist of the mid-thirties. These same individuals now have toe-holds that will stand up and are in a position to evaluate better the individuals who will be needed later for responsible positions of leadership.

Yes—Go West!

The slogan adopted by our Pacific Section is an endorsement of the advice given by Horace Greeley to the young men of his time who wanted to know where opportunity could be found. At that time opportunity meant a homestead and a chance to make a living by tilling the soil. It is doubtful if Mr. Greeley anticipated more than a small fraction of the possibilities of the great Northwest empire.

In each issue of *Tappi,* beginning in April and continuing until September there appears publicity in the form of full page advertisements, detailing the many attractive features planned during the week of September 11 at the TAPPI Fall Meeting at Portland, Ore.

The first two days of the convention will be devoted to field trips. A tour of the Weyerhaeuser Timber Company operations is scheduled for Monday, September 12, for the purpose of demonstrating western logging methods and tree farm development. Both are of major importance to the region in doing the best possible job of wood utilization now and assuring a supply for the future.

On Tuesday, the 13th of September there will be several mill visits of various interests from which to select. These will include the Weyerhaeuser and Longview Fibre mills at Longview, and the Crown Zellerbach mills at Camas and West Linn. Through talks and displays, the visitors will be especially well prepared to fully understand the processes in use in these mills.

On the 14th and 15th of September there will be a number of unusually interesting technical sessions featuring sulphite pulping, kraft pulping, paper making, engineering, and fundamental research.

Foreign Visitors

The central office of the Technical Association has always been the cross-roads of the world in the pulp and paper industry. Over the years most of the visitors to these shores who have been interested in pulp and paper manufacture have considered the TAPPI headquarters as their first port of call. Most of them have arrived with a purpose but a large number have not known how to attain their objectives with a minimum of lost motion and with effectiveness. The Association staff has helped many who have needed guidance.

The objectives always seem to conform to a pattern at the time. At times the visits constitute refresher courses. News about new mills has attracted many. Right now the great majority of visitors are those taking advantage of the opportunities provided by the Economic Cooperation Administration. They are coming here now to buy machinery and other products. Italian paper makers, in particular, are in evidence. In the past Italy was seldom represented among the constant flow of visitors from across the seas.

Vanzyme

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STARCH CONVERTER

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TUB SIZING
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R. T. VANDERBILT CO., Inc.

230 Park Avenue, New York 17, N. Y.

YES! GO WEST! 1949 Fall Meeting—Portland, Oregon

The Technical Challenge of Printing Papers*

Benton R. Cancell (Vice-Pres., St. Regis Paper Co.)

Ladies and Gentlemen of the TAPPI Coating Conference: It gives me the greatest pleasure to be here and to be able to say a few words on the general subject of research and the place of the technical man in the printing paper industry—particularly during this period of economic fear and uncertainty in which we find ourselves.

The paper industry, along with most other industries, has been so prosperous during the past few years in comparison with some of the dismal years of the prewar past, that a major set-back in demand, such as we are now experiencing, seems to many like the "Crack of Doom."

But such a set-back, in some ways, is a good thing. It causes us to do some soul searching and to sit back and take stock—of our mill efficiencies, of the effectiveness of our merchandising, and of the value of our research programs. Anyone can be a hero when the market mill will absorb all that can be produced—irrespective of price and quality of the product. But when demand turns downward and the severe competition which is necessary to the well-being of free-private enterprise again manifests itself, then we find how effective our production methods, our merchandising and research planning, and our execution of such planning has been.

Too often, the real necessity for cutting costs in such a period takes the path of industrial penury, rather than intelligent economy and increased efficiency. At the same time many worth-while research programs are curtailed or abandoned and new programs are not undertaken.

Need Intensified Research

We can only hope that those in executive control of the respective pulp and paper companies in this country will recognize that laboratory and market research should be intensified rather than diminished during periods of economic uncertainty and declining business.

We can only hope, also, that those men charged with the responsibility of developing and carrying out research programs will do so with some regard for end marketing possibilities and commercial values—fostering fundamental research in those qualified institutions where it can be carried out for the benefit of the industry as a whole. Nothing is as ultimately destructive to a company's research program, if it has a program, as long periods of endless research, irrespective of the scale of such research, with no commercial successes to show for the efforts and expenditures of money.

I remember a cartoon in the *Saturday Evening Post* some years ago which illustrates the point I am trying to make. Two little Boy Scouts were on a cliff—one hanging down head foremost with the second holding his feet. The first was searching down into an eagle's nest to pick out some eggs which were there and the angry mother eagle was swooping down on him, claws outstretched. The Scout trying to reach into the nest was shouting up, "Say, maybe we should have found out whether there is a market for eagles eggs before we tried this." It is worth while at this point to examine what research and the technical man has meant in the printing paper industry.

Some time ago, the most interesting prediction was made by a man who was very much concerned over our supposedly rapidly vanishing forest resource—the principal source of raw materials for the manufacture of printing papers—a prediction which we hear very often. What made this particular prediction interesting was that he suggested, at the same time, that the metal magnesium would replace printing papers. It would be called "Graphoil," and would have uniform caliper and breaking strength. Heat-set inks would be necessary to print it, but very high speeds could be maintained on the press, the foil would weigh about 25% of the weight of paper and a thousand page book would be only about $^1/_2$ inch in thickness. It would be plentiful, lightweight, and no more combustible than paper with a cost of about 10 cents per pound.

Until such times arrive, however, we will still be printing on paper—and increasing quantities of paper—despite the vague rumblings and pessimistic forebodings that the television industry will drastically reduce the quantity of printing turned out. These are the same people who were sure that the radio would put all the printers on the bread line. This industry, has somehow continued to grow and furnish the consumer with better products and lower cost printing.

(continued on page 18 A)

* An address given at the TAPPI Coating Conference, Grand Rapids, Mich., April 27, 1949.

For good light fastness...

Du Pont offers:

Lithosol* Red CSP Paste
Lithosol* Fast Yellow HV Paste
Monastral* Fast Blue BWD
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Halopont* Brilliant Pink 2B
Halopont* Brilliant Violet N
Du Pont Brilliant Crocein FL Extra Conc.
Pontamine* Fast Yellow BBL Conc. 125%
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*REG. U. S. PAT. OFF.

Our Technical Staff will help you in the selection of the proper dyes to meet your specific requirements for twisting papers, display papers, cover papers, etc. Cost, color, light fastness and other necessary properties are given full consideration. E. I. du Pont de Nemours & Co. (Inc.), Dyestuffs Division, Wilmington 98, Delaware.

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BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

(continued from page 16 A)

End-Use Limitations

But it has not always been so, for there have been long periods when the industry has advanced very slowly, not entirely because business may have been bad, but in part because there were no particular advances in printing or papermaking to stimulate research and development of new sheets.

With the exception of the development of machine coated papers, I believe that it can generally be said that the 15 year prewar history of printing paper production was, by and large, one of concentration upon standard brands and mill grades, particularly by the larger manufacturers, with no other major advances in new papers.

The end uses of our printing paper grades were, in turn, limited by the basic raw materials with which we worked—3 or 4 grades of wood pulp, a few sizing materials, a limited number of adhesives, and a few types of clay and mineral materials.

A number of combinations and additives to these materials accounted for all of the printing papers offered by the industry. New grades of paper, marketed by one manufacturer, were closely duplicated over a period of time by another manufacturer, when he decided to broaden his line. Oftimes, it was only the skill (or lack of it) of the papermaker himself, that determined the competitive success of the sheet, rather than new materials or new or inherent scientific knowledge or ability.

In the field of printing, quality work on coated papers was largely by the letterpress process, with offset and gravure printing almost entirely on uncoated papers. The development of heat-set inks and, in turn, high-speed presses, along with the development of machine coated papers, ended the era to which I previously referred—a period of relatively few standard brands and mill grades.

Machine-Coating

Mail order catalogs were among the first to adopt the machine coated papers because of the new brilliant results they could obtain with heat-set gloss inks. Moreover, the development of the new lightweight machine coated sheet, containing a high-groundwood content to provide good cushion and opacity, contributed to economy, quality, and fast production on tight schedules. The result of these developments was an immediate increase of more than 50% in the number of color pages in the catalogs of four of the largest mail order houses.

By the use of heat-set inks and fast rotary presses, 40-lb. machine coated papers are now being used with good quality reproduction, where 50-lb. machine coated sheets were used previously on slow sheet fed presses.

But it is interesting to note that the over-all consumption of off machine coated papers has not diminished. Machine coated papers have merely expanded the use of printing papers.

Such technical advances in the printing paper industry have been great during the past decade—partly because of the necessity created by the war, and by the stimulus of particular wartime research projects, partly because of postwar prosperity, and lack of wartime restrictions fostered research, but also, in no small measure, because the admirable technical and mechanical advances of the printing and publication industry forced the development of new and more specialized printing papers.

The continual improvement of machine coated papers, and the comparatively low cost of these papers, has been equally a stimulus and a threat to both the off machine coated and uncoated printing paper field.

The former, under competitive pressure from machine coated papers, have improved materially, but the cost of off machine coating is comparatively high. True, in printing qualities, machine coated papers have only equaled the lower grades of brush coated sheets, and off machine coated papers still remain supreme where quality of production is paramount, and where waterproof coatings are a necessity. But the intensity of laboratory and operational research in new and improved machine coated processes and equipment is such that the next few years may see considerable replacement of off machine coated papers—unless they are further improved and major economies in their production are achieved.

The industry already has on hand many of the materials and techniques for so changing the characteristics of a sheet of paper as to impart practically any property required—within reason, of course. It requires only that the proper machines be built and the fundamental laboratory work completed—a long and difficult, but not impossible task.

Related Developments

The growing synthetics and plastics field is probably the outstanding source of many new and most effective additive raw materials used in the manufacture of both coated and uncoated printing papers. It is possible that once quantity production permits price reduction of some of these materials, a considerable replacement of hard to handle filler and coating clays may take place. The laboratory experiments are already showing, among other things, that some synthetics are more ink-receptive, finish up with an extremely high gloss, and have no tendency to dust out of the sheet. We know the clay industry likewise is moving rapidly research-wise, and it may be that our friends in the clay industry have something up their sleeves which will permit clays, alone, or in combination, to do the same things better and at a lower cost. There are also the new resin adhesives, more efficient than casein or starch, which may eventually prevent picking of a coated surface—no matter what the tack or pull of the printing ink—which can eliminate the cracking of the coating on fold—and which will waterproof the sheet at the same time.

In the field of uncoated printing papers, laboratory work of suppliers, as well as laboratory and mill work in the paper industry, shows that when desired, we can approach the flexibility and pliability of cloth through beater additions of resins. In the uncoated groundwood papers, peroxide bleaching has improved the printing qualities and the printing of the sheet to where it has become a most desirable type of printing paper.

I spoke a few minutes ago about our supposedly

(continued on page 20 A)

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Uniform Bulk Starch!

Uniform in texture…color…cleanliness. The same basic corn starch that is used in National's finest starch specialties is now available to you in carload quantities.

Bulk Corn Starch processed with precision controlled uniformity!

National separates all of its starch from gluten with high-speed, stainless steel, fully enclosed MERCO centrifugals. 100% mechanically! Complete separation in 3 to 5 minutes, instead of 10 to 12 hours by the open starch table method.

Drastically reduced processing time has greatly increased our production of ***Hoosier Pearl and Powdered*** bulk starches. Specialties, too, are available to meet your increased requirements for ***Paper Makers' Controlled pH Corn Starch . . . Chlorinated Corn Starch . . . Thin Boiling Corn Starch . . .*** and ***Dextrines.***

Always available: Technical service! Call on our laboratory anytime. Delivery! Prompt CL or LCL shipments from our plants or convenient warehouses.

Write for full details: 270 Madison Ave., NEW YORK 16; BOSTON, PHILADELPHIA, ATLANTA, HOUSTON, INDIANAPOLIS, CHICAGO, SAN FRANCISCO and other principal cities. Other National facilities—in Canada: National Adhesives (Canada) Ltd., Toronto and Montreal. In Holland: Nationale Zetmeelindustrie, N. V. Veendam.

BULK STARCH
BULK STARCH
BULK STARCH

National
STARCH PRODUCTS

(continued from page 18 A)

diminishing supply of wood. I doubt that this situation is as serious as it sounds—although it may be for the lumber industry where big trees are required. So far as paper is concerned we seem to be on the verge of major success, both in this country and in Canada, of developing semichemical and high-yield pulps which will not only extend the resource of presently used pulpwoods, but will tap hitherto unused species of wood which exist in great quantities. The fundamental research and laboratory work has been completed, or nearly so, in both countries and it seems fairly clear that these pulps will, in time, produce better printing papers—papers with more cushion and greater opacity —and because of the high yields from wood—at lower cost.

Technical Men in Sales

There has been a tendency in the industry, and particularly on the part of the sales people, to consider the research and technical man a rather bookish individual, buried away with his test tubes and beakers in the dim recesses of some laboratory. He has been considered as having no place in either the manufacturing or merchandising of paper. Yet a little thought reveals that the contributions of the technical man have made possible the advances I have so briefly discussed. It is the technical man who has given us coated papers and made possible reproduction by the multicolor process. He has also accounted for the stronger printing papers that permit the amazing speed of some of the presses today—thereby achieving lower costs of printing and greater consumption of paper.

But an interesting and significant change is taking place. More and more, the technical man, in addition to his place in research and development, is handling sales service problems, and in many progressive companies, he is moving into actual sales. This is not strange when one considers the meaning of the term "quality of reproduction" in the graphic arts industry, and the constantly greater requirement for specialized papers in many branches of printing.

A great many people in both the paper industry and the graphic arts industry depend on quality of printing for their daily bread—and yet do not know what makes a printed job good or bad. They may know whether the over-all impression is pleasing or mediocre, but try to pin them down as to why they think as they do. Take the printing paper salesman—when the printer wants an explanation as to why the last shipment of paper does not stack up, the salesman must be able to give it to him in other than vague generalities or the customer is likely to go elsewhere for his next order.

Yet we have many salesmen in the industry today who have no conception as to why a waterproof, surface-sized sheet is required for offset printing—or, for that matter, what offset printing is. Machine coated papers are sold for jobs where 150-line screens are printed and then both the salesman and the customer complain to the mill about the quality of the reproduction, not knowing that this type of lightweight coating can not equal a fully coated sheet in printability of so fine a half-tone screen.

Paper is sold for spirit or press varnishing which was never intended for this purpose—simply because the salesman is not familiar with the process—or the difference between the two.

Gravure printing—a highly technical process, which, like offset, accounts for an increasingly large consumption of paper—demands a sheet satisfactorily made for the purpose. Yet, time and again, there are salesmen who recommend any sheet that happens to be on hand.

Heat-set, cold-set, and steam-set inks are in relatively common use in the industry; and being used on faster presses, each type introduces a new factor into the grade of paper used. Here again, we find many similar sales difficulties.

The fact is that the technical man actually engaged in the development of these products has the opportunity of combining his technical know-how with a better appreciation of what makes the paper saleable.

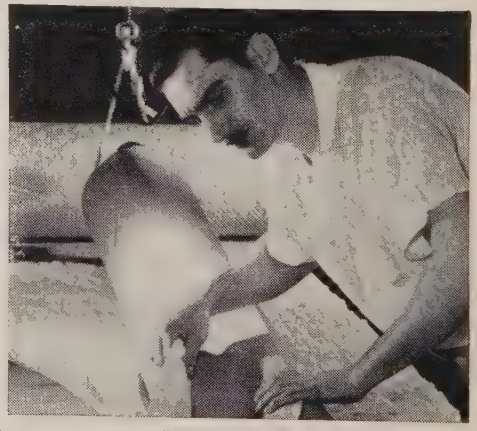
In conclusion, the importance of continuing research both laboratory and market-wise, in an industry such as ours, is all important. It is particularly important today to maintain and to improve the quality and lower the production costs of our present products, to develop new products, and to expand the uses for the products of this industry, so that it continues to be as it has been in the past, a vital force in the American economy.

One of the Men Behind Eastwood Wires...

Jack Cove

Knows how to "baby" fourdrinier wires

After all the care that goes into fashioning Eastwood wires, Jack Cove won't let anything happen to spoil their perfection. That's why he carefully makes a "cocoon" of soft packing to protect the finished wire. Next, he cradles it in a strong wooden box. All of this loving care is taken to make sure the wire reaches the mill in perfect condition, ready for a long and useful life of papermaking. Eastwood employees know that our wires represent *their* reputation too.



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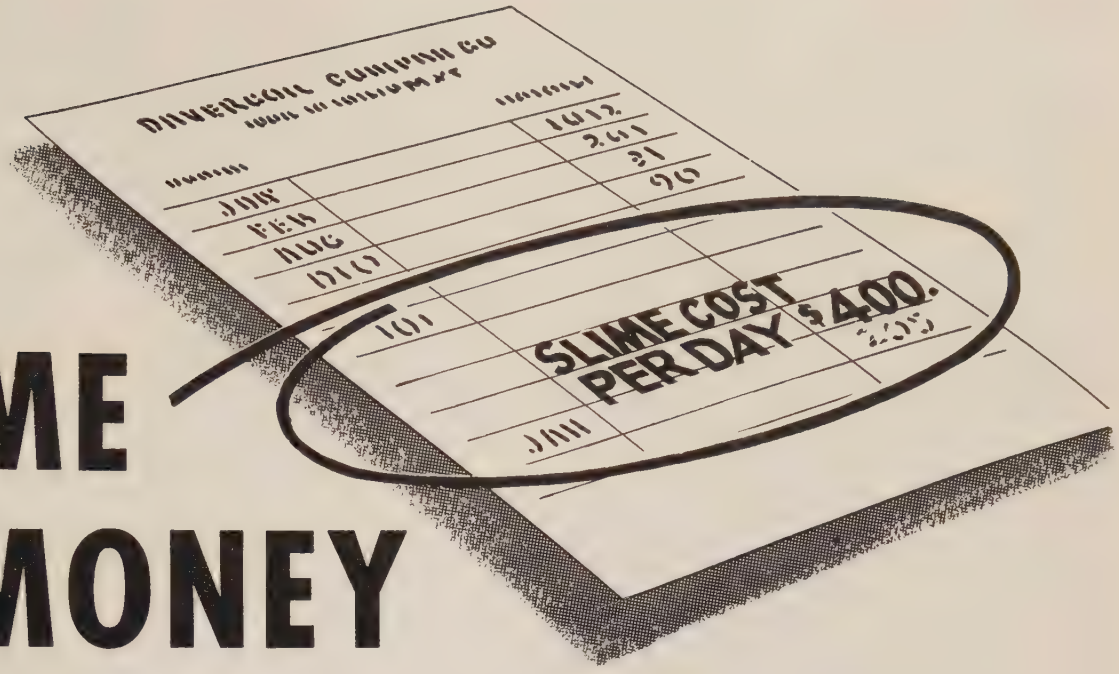
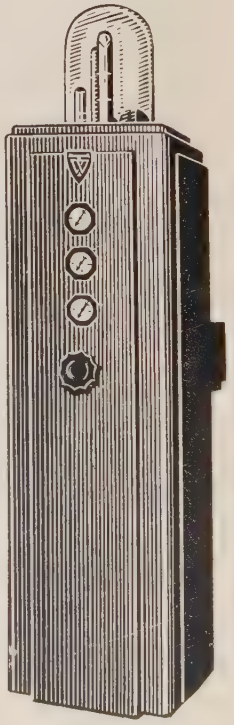


SLIME IS MONEY

Although you may never see a bill, studies show that slime costs the average paper mill $400 or more a day and is responsible for such costly troubles as wet end breaks, pin holes, slime spots, poor sheet formation, etc.

Break-Point Chlorination, engineered to your particular needs, has proven its slime fighting ability in hundreds of installations. This process, applied by dependable W&T Chlorinators, to your fresh water supply, often in conjunction with chloramines or other corrective chemicals to your stock or white water, gets results because it destroys the very cause of the trouble — slime forming bacteria. Moreover, members of W&T's nation-wide service organization with over 35 years' experience at their fingertips, carefully engineer each installation, to insure that you will receive maximum protection against slime at the lowest possible cost.

Your nearest W&T Representative will be glad to give you full details on how Break-Point Chlorination can cut your slime costs. Call him today.



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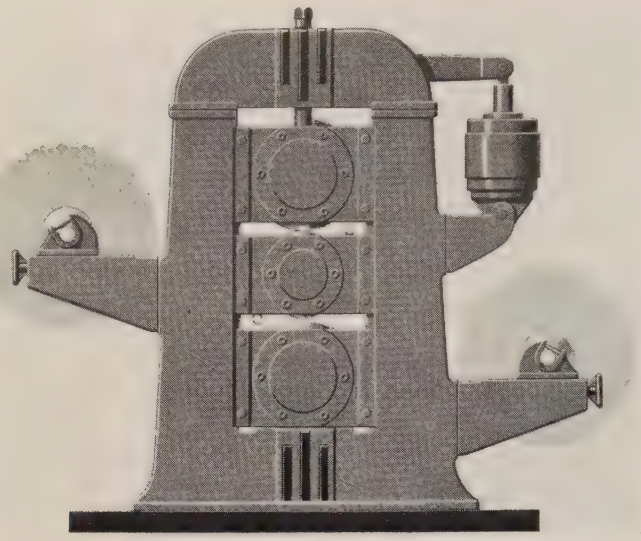

as a SUPERCALENDER
MACHINE CALENDER
CALIPER CALENDER
SHEET CALENDER

Appleton Laboratory Models can be furnished in any one or more of the following combinations—as a SUPERCALENDER, with two chilled iron rolls and one filled roll; as a MACHINE CALENDER, with all chilled iron rolls; as a CALIPER CALENDER, with micro adjustment for roll spacing; and as a SHEET CALENDER, for processing sheets. Applied pressure can be either Pneumatic or Screw Down. Here is a precision built three roll unit, capable of a wide variety of adaptations for economically working out finishing problems in the laboratory for technical control and development of paper and fibrous sheet and web finishing and coating. Write for detailed specifications and full information, indicating your requirements.

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Laboratory Calenders • Experimental Supercalenders • Web Supercalenders • Glassine Supercalenders • Embossing Calenders • Friction Calenders • Cotton, Paper, Laminated and Special Process Supercalender Rolls • Chilled Iron Rolls • Embossing Rolls • Unwind and Windup Reels • Winders • Tension Controls • Hydraulic Pressure Systems • Oiling Systems • Brakes Operating Control Panels • Roll Trucks • Etc.

SPECIALIZATION in paper finishing

Calls for control of many variables

At the time TAPPI was organized, a few standard hard and soft filled rolls met most of the superfinishing requirements of the day. Now each application is custom-built for particular results. Staffed by the largest scientific and technically educated personnel in any industry, paper making leaves little to chance.

Many variables influence the proper finishing of paper. Fiber content, binder pigment, moisture content, caliper, temperature, pressure, operating speeds, roll size and density, fillings and coatings—these and others help to determine the quality of the finish on a sheet of paper. Specialization and new developments only emphasize the importance of controlling these variables to obtain uniformity and high quality finish.

As a supplier of the mechanical equipment for supering paper, Appleton extends every effort to provide the precision operation that makes control of many of the variables possible. The latest engineering refinements for smooth performance and accurate control are incorporated in Appleton Supercalenders—for the laboratory—for experimental runs—for every application in the mill or finishing room—in Appleton's complete selection of filled rolls—and in Appleton auxiliary equipment. Mill technicians and Appleton engineers work together to improve and control the quality of finish on paper.

SINCE A 1883

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Eastern Sales: CASTLE & OVERTON, Inc., 630 Fifth Avenue, New York • Western Sales: PACIFIC COAST SUPPLY CO., San Francisco • Portland

FOR SMOOTHER FINISH

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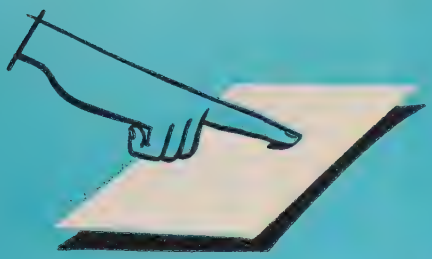

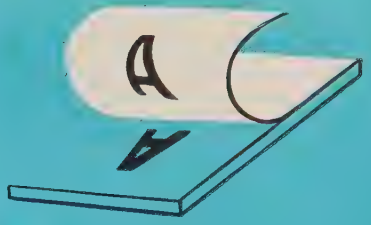

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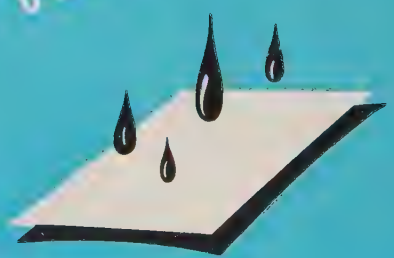

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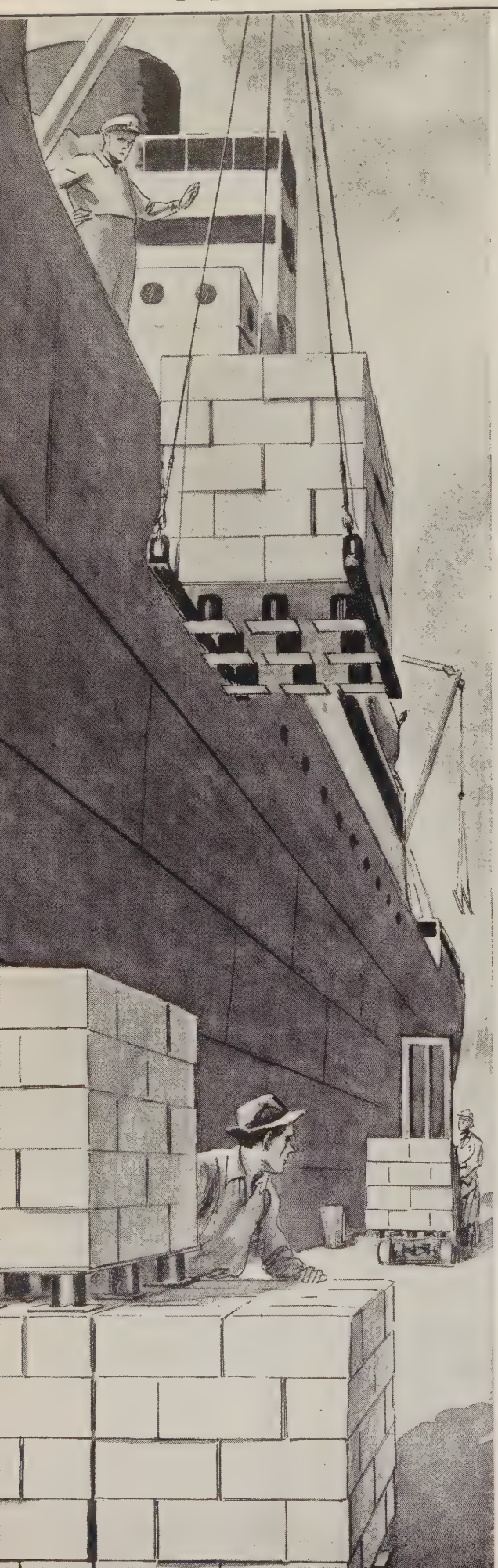

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(NEWS ITEM: *Disposable 8-lb. paper pallets are replacing 60-lb. wooden skids for economical shipment of large unit loads.*)

A new method of reducing freight costs is the use of water-resistant paper pallets that can be discarded at the end of a trip. Made of a corrugated paperboard platform supported by spiral chipboard tubes, these paper pallets can carry static loads of 18,000 pounds in transit by plane, truck, rail or ship. We will gladly supply manufacturer's name on request.

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To meet these new responsibilities and new opportunities developed by the Pulp and Paper Industry, the Puseyjones Organization is now devoting itself completely to the design and construction of Paper-Making Machinery built to new high standards of speed and efficiency, and to the modernization of existing machines.

Additional capacity in Metals Fabrication is now available through conversion of facilities formerly devoted to the building of ships.

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THE SIGN OF TRADE MARK SUPERIOR QUALITY

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WEST
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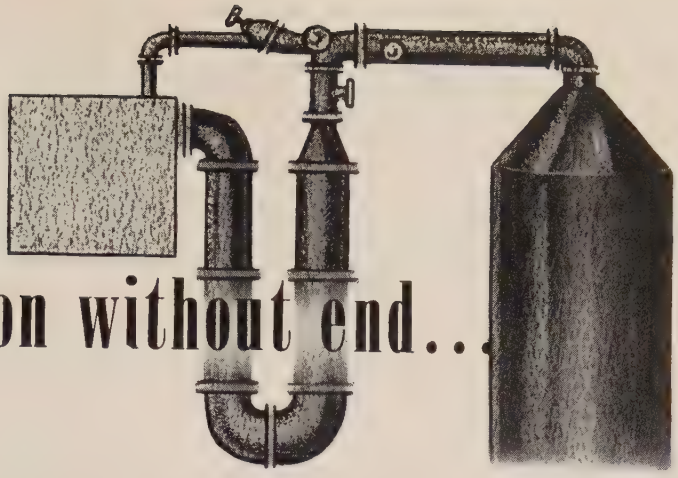
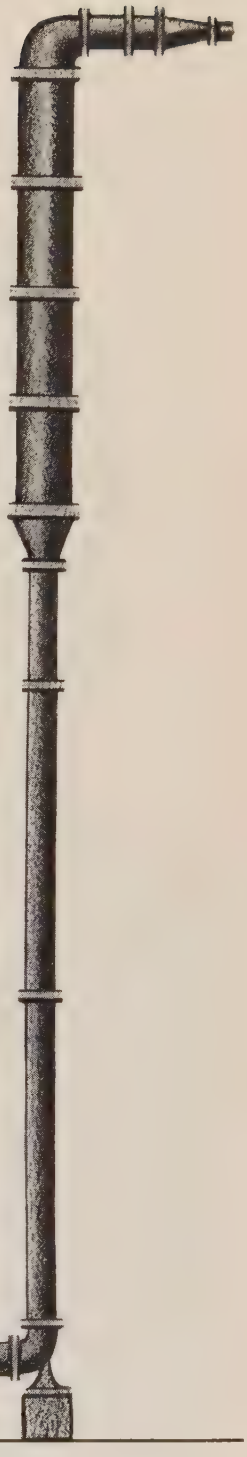


Chlorination without end...

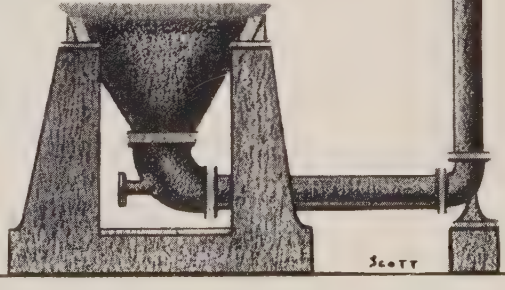


AFTER the introduction of direct chlorination by Hooker engineers and technologists, they then tackled the problem of substituting a continuous process for the batch system of operation. The major obstacle to this change-over was obtaining materials of construction that would stand up under prevailing acid conditions.

Pulp chlorinating equipment of rubber-lined iron and steel proved economical and durable. The design of this equipment was followed in 1931 by the introduction of another Hooker contribution, a rubber-lined mixer based on the baffle principle. The first installation was at Muskegon, Michigan, where it successfully handled 30 tons a day on a continuous basis.

With these improvements the Hooker Chlorination process was now practically automatic and served as a test for chlorine demand. Correct operation for any given grade of pulp resulted in a uniform concentration of residual available chlorine at the end of the acid period. Occasional tests of the chlorinated stock were sufficient and variations in chlorine demand were taken care of by varying chlorine flow so as to maintain a uniform concentration of residual chlorine.

From these early improvements, pulp and paper makers have made greater and greater progress. Hooker chemists and technologists have continued to work hand in hand with the industry on these developments. Along with this co-operation is the help they give in continuing to provide uniform high quality chlorine, caustic soda and the other chemicals without which no lasting progress can be made. Other helps are in the form of informative literature. A list of the bulletins available will be sent you when requested on your company letterhead.



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HOOKER CHEMICALS

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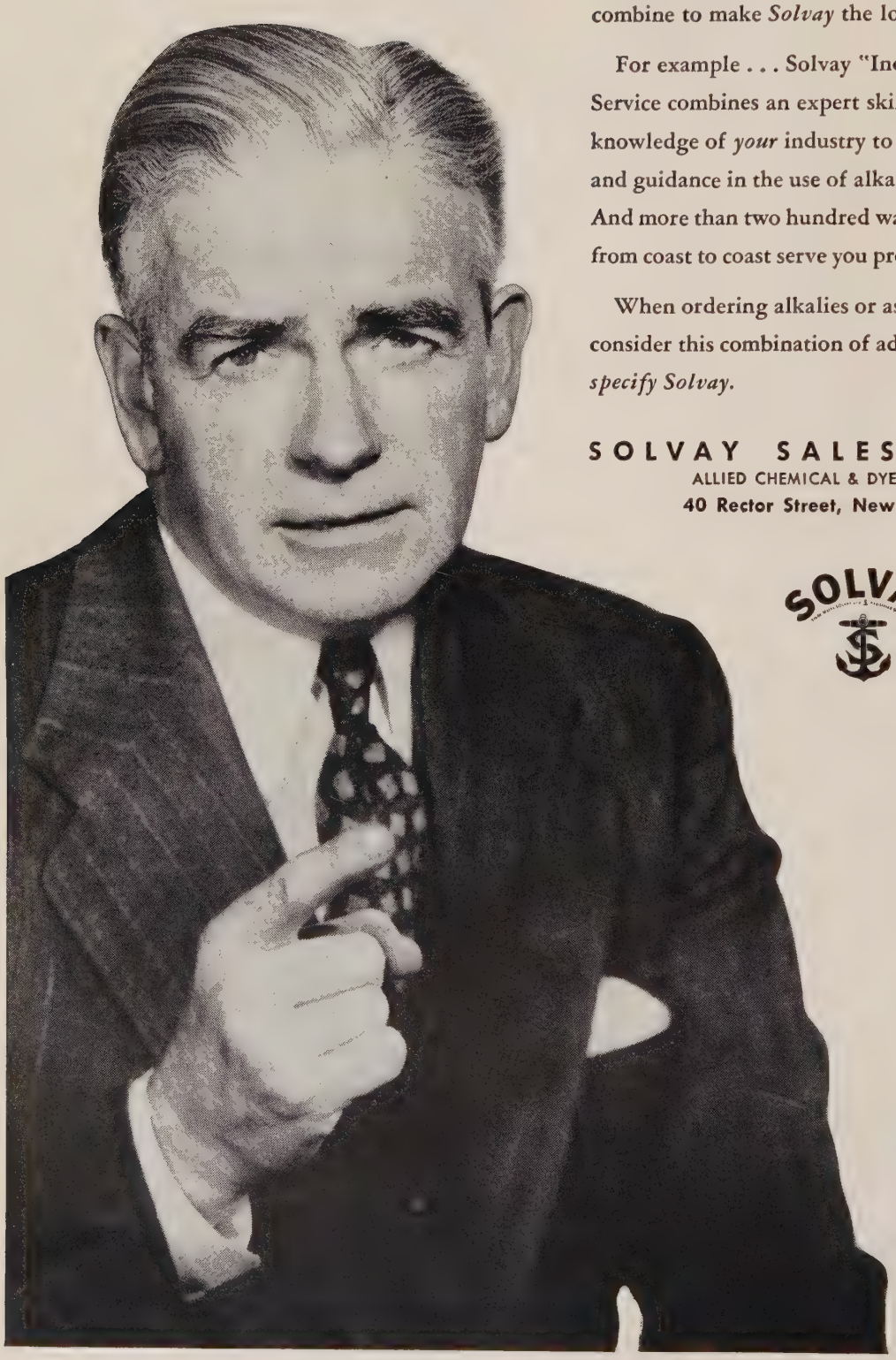
"Why You Should Specify SOLVAY"



Chemicals are not bought on the basis of price and specifications alone. Other factors must be considered . . . plant facilities, plant locations, length of experience, Technical Service, convenience of warehouse locations for prompt and economical delivery. All these combine to make *Solvay* the logical choice for alkalies.

For example . . . Solvay "Industry-Wise" Technical Service combines an expert skill in alkalies with an intimate knowledge of *your* industry to offer invaluable counsel and guidance in the use of alkalies and associated chemicals. And more than two hundred warehouses and stock points from coast to coast serve you promptly and economically.

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- Chlorine
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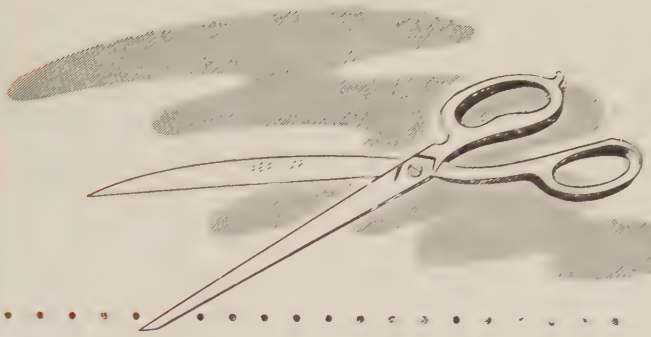
- Specialty Cleansers
- Ammonium Bicarbonate
- Sodium Nitrite
- Para-dichlorobenzene
- Ortho-dichlorobenzene
- Monochlorobenzene
- Methanol
- Ammonium Chloride
- Formaldehyde

cut PAPER with



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save FIBER, FUEL WATER, CHEMICALS

solve STREAM PURIFICATION PROBLEMS

Sveen Pedersen Flotation Saveall cuts mill waste more effectively than the conventional type savealls. Its flotation action recovers more fibers and fillers; water is clarified to such a high degree of purity that it can be extensively re-used in the system. Sveen Pedersen greatly reduces fresh water and fuel consumption, and virtually eliminates stream improvement problems.

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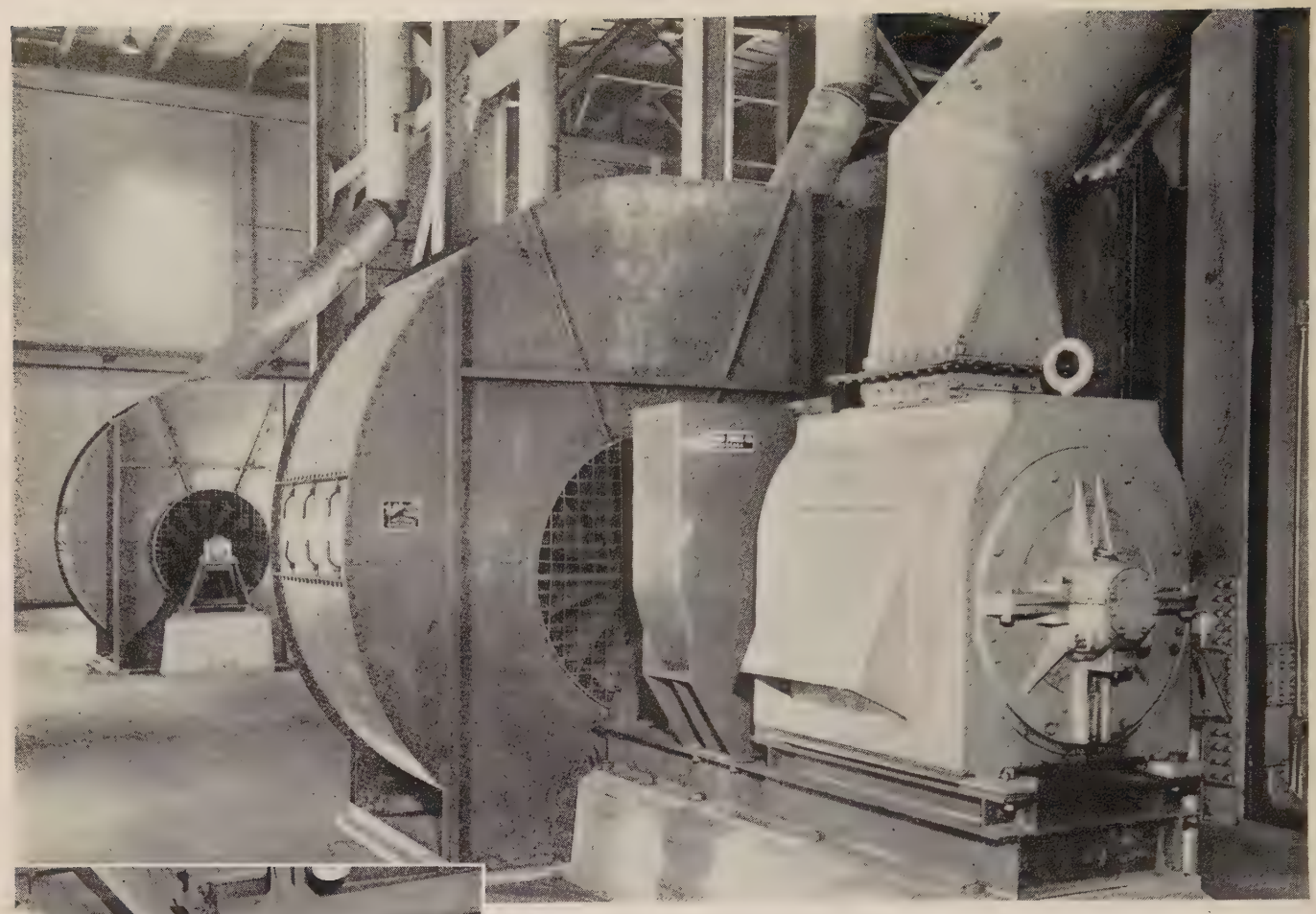

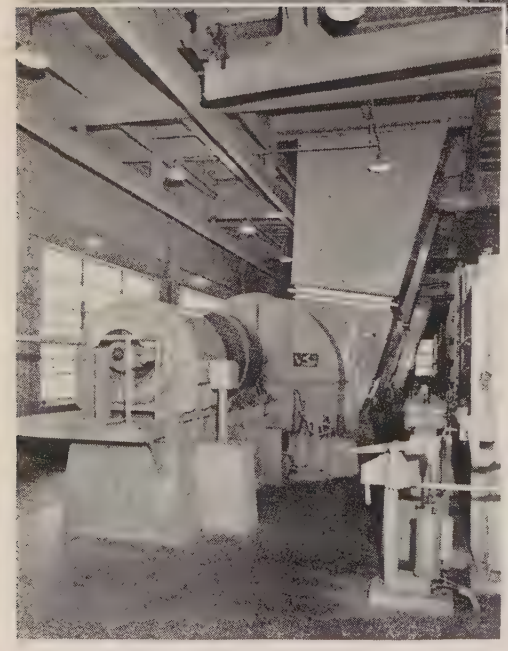

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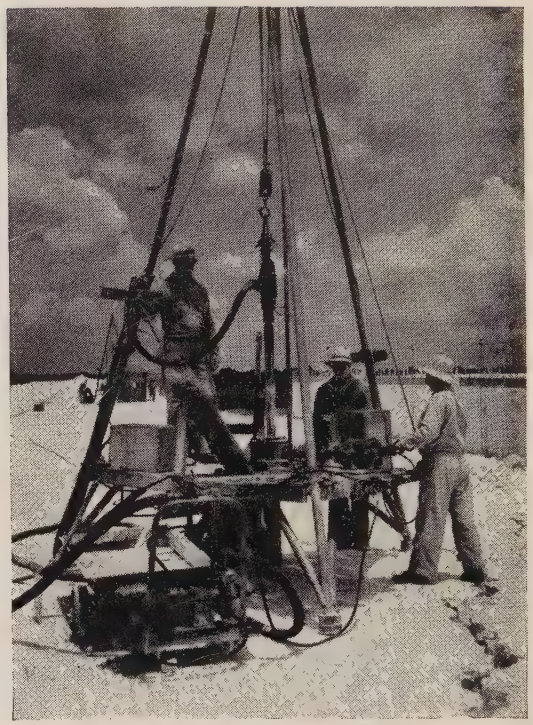

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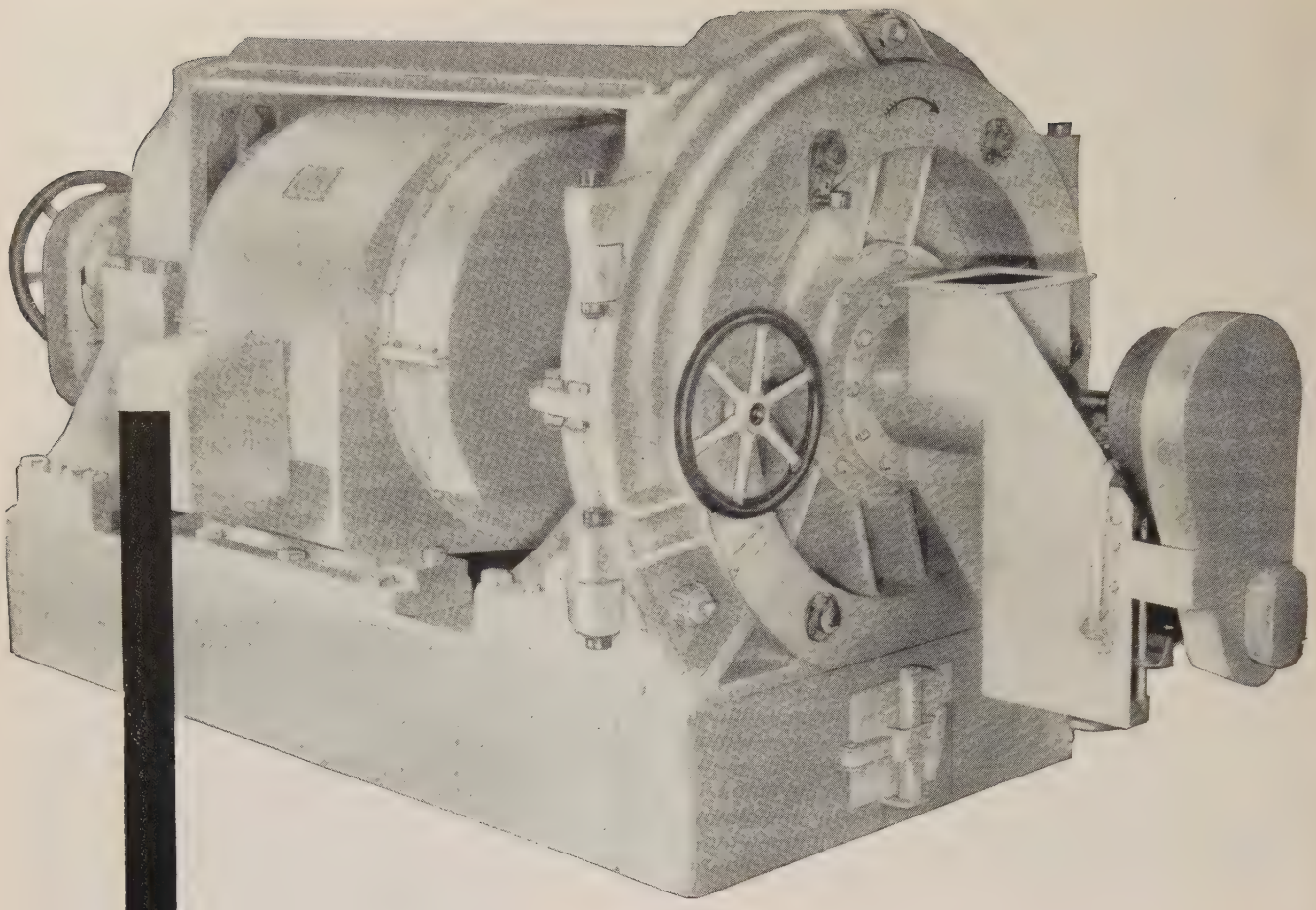

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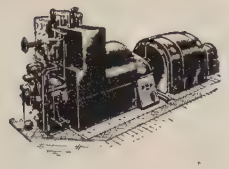
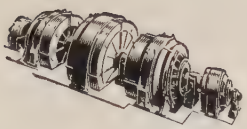
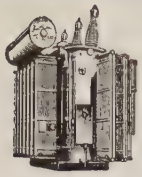

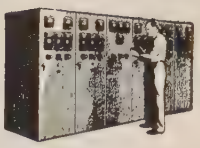

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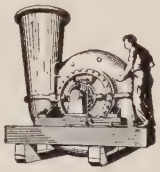

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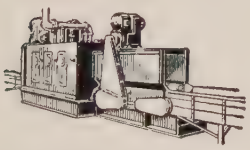
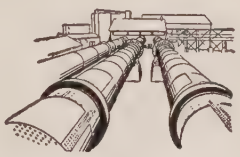

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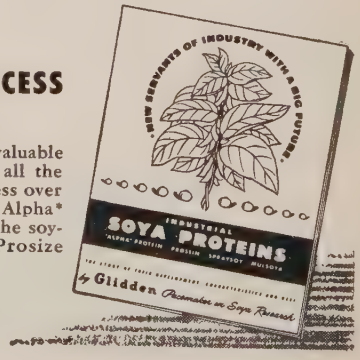

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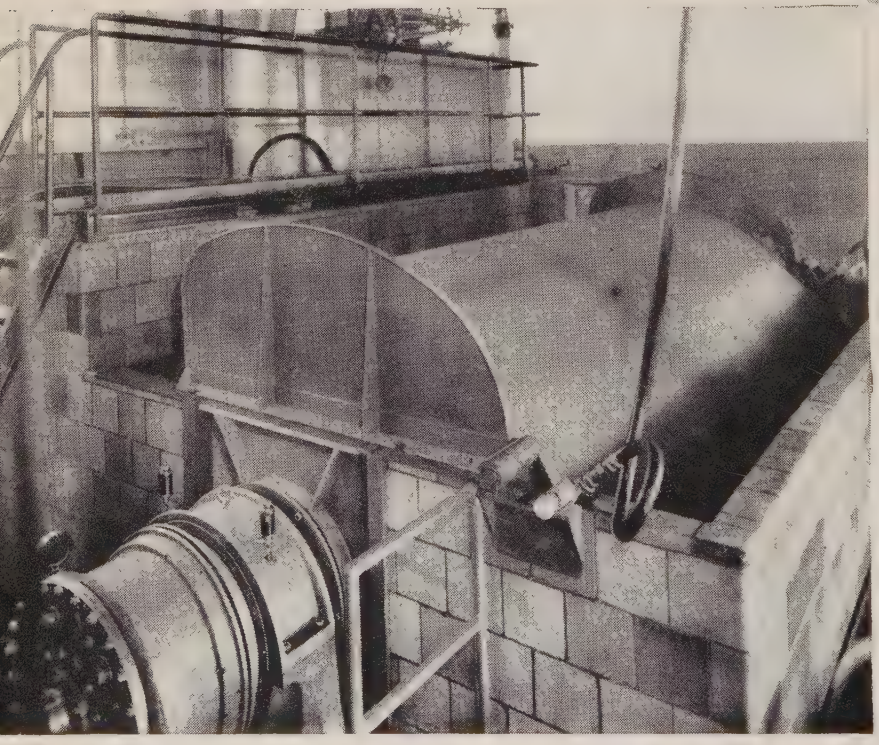

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Sulphidity in the Sulphate Process

ERIK HÄGGLUND

THE QUESTION of the function of sodium sulphide in the sulphate cooking process has been a subject of research for many years and has had many interpretations. In the beginning the most preposterous explanations were advanced. For example, it was believed that the sulphide was oxidized to sulphate by oxygen obtained from the organic compounds found in the wood or in the liquor. The favorable effect that sulphate cooking apparently had on the quality of the pulp led Klason, in his time, to assume that the sodium sulphide gradually hydrolyzed into sodium hydroxide and sodium hydrosulphide during the course of the cooking, and therefore the alkali effect on the cellulose would be less. This is, as was pointed out long ago, incorrect since, under actual sulphate cooking conditions, the sodium sulphide is practically completely hydrolyzed at the beginning of the cook.

Klasons's observation that the lignin in "black liquor" contained sulphur was an important development. He did not, however, draw any conclusions from this regarding the reaction mechanism. Later Kullgren theorized that solid lignin took up sulphur and thus became more soluble in alkali.

For an illustration of the difference in the speed of dissolution in a pure alkali cook and a sulphide cook using white liquor of different sulphide contents, reference is made to Fig. 1 from an investigation carried out by Hedlund and the author. The cooking took place at 160°C. and the alkali ratio, that is the amount of active alkali expressed as sodium hydroxide in per cent on dry wood, was 24.2. The rate of dissolution of lignin increases with increased sulphide content, but it is evident that the last residue of lignin in the pulp dissolves very slowly. As a consequence the cooking time of pulp with the same degree of delignification (Roe Number) can be considerably reduced by increasing the sulphide content of the white liquor. This is illustrated in Fig. 2, which also shows the results of runs made at different maximum temperatures. In order to obtain a Roe Number of 5, one must, for example, at 160°C., cook only $6^1/_2$ hours with 40% sulphidity in contrast to $9^1/_2$ hours with 12% sulphidity. It follows from this, that wood need be exposed to the effect of the alkali for a shorter time with higher sulphidity to obtain the same degree of delignification.

How this affects the pulp's properties is shown in Fig. 3, which shows the tensile strength after cooking at a maximum temperature of 160°C. It is obvious that the strength is decreased by decreasing the sulphidity. It has been a popular belief among cellulose technologists that this fact should manifest itself in a breaking apart of the pulp fibers during the cook. If one conducts a microscopic determination of the distribution of fiber lengths in pulp cooked with white liquor of different sulphidities, no such difference can be found. If such a difference should exist it would be exactly the opposite (Fig. 4). When different pulps are subjected to beating, characteristic differences can be observed as is shown in Fig. 5. After 15,000 revolutions in a Lampén mill, pulp cooked with 40% sulphidity was characterized to but a very small degree by broken fibers. The increase in the beating degree in this case was mostly due to fibrillation. Cooking with pure alkali gave, on the other hand, an obviously brittle pulp which fell apart with beating into short pieces of fibers.

The author shall now return to the question of why thiolignin, in the solid state, dissolves easier than a nonsulphur-containing lignin. Investigation was begun by the author 25 years ago in research conducted together with Trygg. This was later followed by work at the Regal Institute of Technology and, still later, at the Swedish Forest Products Research Laboratory in Stockholm. As colleagues, the author has had, in chronological order, Ringström, Giertz, Enkvist, and Moilanen, as well as Johansson for some analytical questions.

The following results of these investigations may be cited. By cooking spruce with a solution of sodium hydrosulphide at, for example, a temperature of 160°C., a considerable amount of sulphur is organically bound in the solid phase. The greatest amount of lignin remains in the wood. Only about one fourth goes into solution and in such a form that it cannot be precipitated with hydrochloric acid. This so-called "water soluble" lignin will be considered later. The lignin existing in the wood has been changed in composition so that it can, to a considerable extent, be brought into solution under mild conditions, for example, by cooking with 5% sodium hydroxide under atmospheric pressure or by extraction with organic solvents such as 75% alcohol. In the first case, lignin, precipitated with hydrochloric acid, is obtained in a

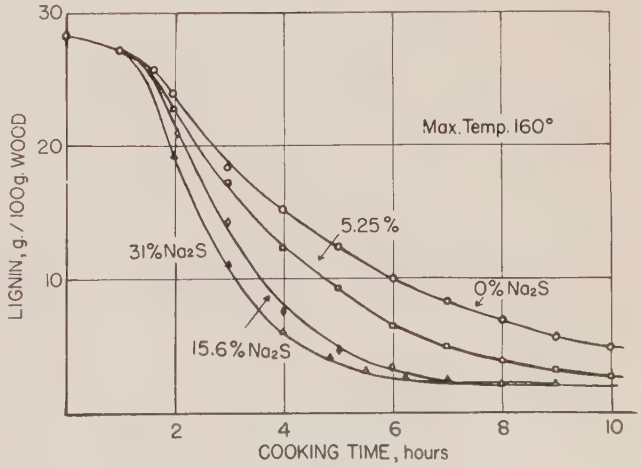


Fig. 1

ERIK HÄGGLUND, Member TAPPI; Professor, Svenska Träforskningsinstitutet, Stockholm, Sweden.

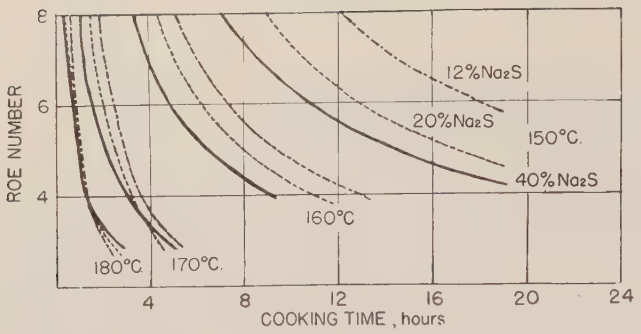
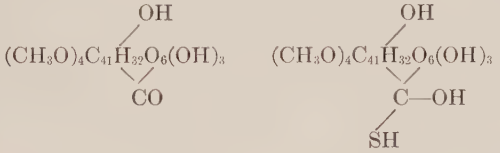


Fig. 2

yield of 10% of the wood's weight and contains 8 to 9% of organically bound sulphur. In the second case, a yield of 5% is obtained with a content of 11.9% organically bound sulphur (methoxy content 10.9%).

If one delignifies with sodium sulphide, the greatest amount of lignin goes into solution. Lignin, precipitated from this solution with hydrochloric acid, has a sulphur content of only about 3%. Ahlm has also investigated this type of lignin. On the basis of methylation and acetylation, he has advanced a suggestion regarding the interpretation of the origin of thiolignin which is represented in the following formula:



Native Lignin (Brauns) Thiolignin (Ahlm)

Thus thiolignin should originate by the addition of hydrogen sulphide to a carbonyl group in the lignin, whereby mercaptan and a hydroxyl group are formed. The mercaptan group formed should give lignin increased acid properties, and this would explain the greater alkali solubility of thiolignin than sulphur-free lignin.

The results of the aforementioned two-step cooking procedure—sodium hydrosulphide at 160°C. and dissolution by cooking with dilute sodium hydroxide—obviously cannot be explained by means of Ahlm's theory. An 8 to 12% sulphur content in thiolignin would be equivalent to a carbonyl content in lignin which is considerably greater than that which can actually be shown to exist. F. S. Hansson has, like the author and his co-workers, found thiolignin with over 10% sulphur. He also assumes, therefore, that

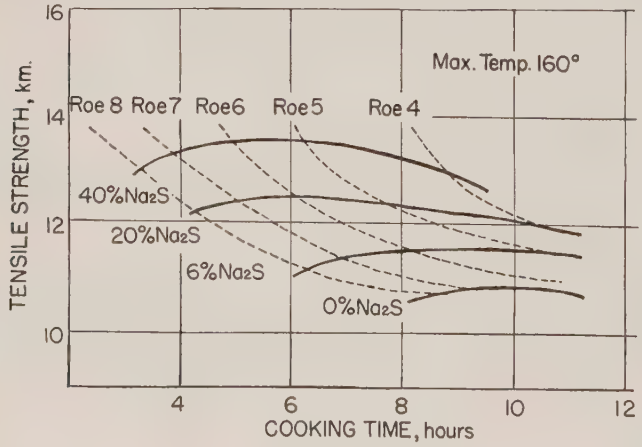


Fig. 3

SH groups can replace hydroxyl groups in lignin. The fact that we could not find any appreciable amount of mercaptan sulphur by titration of thiolignin with iodine in alcohol solution, also is against Ahlm's theory. Now it is known that mercaptan groups are easily dehydrogenated to disulphide groups even by air, but that these easily reform mercaptans on reduction, for example, with zinc and dilute acids. However, even after such a reduction, it has not been possible to show large amounts of disulphide sulphur in thiolignin obtained from cooking with sodium hydrosulphide.

Ahlm has found that thiolignin forms precipitates with mercury acetate in glacial acetic acid solution and regards this to be a support for his opinion that thiolignin contains mercaptan groups. It is known, however, that organic sulphides also give precipitates with mercury salts, and we have found that this also occurs in glacial acetic acid solution. We have come to the conclusion that the sulphur in the thiolignin in question is mainly bound as a sulphide.

As a further contribution to the knowledge of sulphur-lignin, the following investigations are discussed.

If resin-free spruce is heated for 3 days with a buffered saturated hydrogen sulphide-water solution at a pH of 7 at 100°C. the solid wood takes up 1 to 2% of sulphur. By mild warming with weak sodium hydroxide or soda solution, or simply by extraction with organic solvents, pyridine, for example, or also neutral solvents such as 75% alcohol or dioxan in a Soxhlet apparatus, a thiolignin preparation is obtained which contains 12 to 18% organically combined sulphur. The yield of thiolignin is about one tenth of the lignin in the wood. If the residue, after extraction, is again treated with hydrogen sulphide and extracted with pyridine, about one tenth of the wood's lignin content is again dissolved. We have continued this treatment up to eight times. The results are shown in Fig. 6. As can be deduced, the yield of thiolignin at each cook drops slowly to about a third of that which was obtained at the beginning of the treatment. In all, about 60% of the wood's total lignin content can be dissolved in this manner. At the same time, some of the carbohydrates have also gone in solution equivalent to about two thirds of the amount of lignin dissolved. The proportion of dissolved lignin to dissolved carbohydrates is not constant but decreases from 2.4 to 1.3. The content of organically combined sulphur in the residue after pyridine extraction remains very constant at about 1% of the original wood. If one determines the sulphur content in lignin isolated from 72% sulphuric acid, a value of 4.2% is obtained. A sulphur content of this size is equivalent to about 1 sulphur atom per 40 carbon atoms. This value forms, in this and many other cases, a sort of limiting value to the possible sulphur content in undissolved thiolignin. If the sulphur content increases essentially over 5%, the thiolignin becomes easily soluble in alkali and organic solvents.

After the eight hydrogen sulphide cooks and pyridine extractions, the undissolved wood contains 17.1% lignin as well as 2.11% methoxy groups. The wood cannot be reduced to fibers, nor is it swollen. Under a microscope it has the same appearance as the unreacted wood excepting a similarly distributed yellow

brown color. In ultraviolet light, the middle lamella appears very dark due to the absorption of the lignin. In the secondary walls, however, the coloration has been greatly weakened. Apparently the dissolution of lignin has not seriously affected the middle lamella.

Thiolignin, prepared by the effect of hydrogen sulphide on resin-free spruce at 160°C. and a pH of 7, is called "hydrogen sulphide lignin" in the following discussion.

The chemical properties of the prepared thiolignin should be considered somewhat more closely and compared to sulphur-free alkali lignin. First, there is the question of how the sulphur is combined in the sulphur-rich lignin. It has been shown that no splitting off of sulphur occurs by cooking with dilute hydrochloric acid. With dilute sodium hydroxide only a small amount of hydrogen sulphide is formed. If the temperature is increased to 160°C. and maintained for 3 hours, the sulphur content, in a sample preparation, decreased from 8.45 to 4.10% with the formation of a considerable amount of hydrosulphide in the solution. Here lies the explanation for the fact that the sulphur content in lignin from a technical sulphate cook is as low as 2.5 to 4%.

As far as solubility in alkali, such as sodium hydroxide, soda solution, and ammonia are concerned, thiolignin is very similar to sulphur-free alkali lignin obtained from a soda cook. They behave as substances of a phenolic nature, but differ sharply from hydrochloric acid lignin and cuproxam-lignin which are not soluble in sodium hydroxide except after long heating at high temperatures.

Thiolignin is not homogenous. By dissolving in dioxan and precipitating with alcohol or ether, the lignin can be separated into an ether-soluble, alcohol-soluble, and dioxan-soluble thiolignin. From the hydrosulphide cook at 160°, a considerable amount of substances is also obtained which is soluble in sodium hydroxide at 105° but not in organic solvents. By such separations, it has been shown that sulphur lignin is not homogenous since its sulphur content can vary within wide limits, for example, between 7 to 18%. It should be noticed that a sulphur content of 14.6% in lignin is equivalent to one sulphur atom per ten carbon atoms. Very high sulphur contents are found in hydrogen sulphide lignins. It was shown by iodine titration after reduction that they contain a considerable amount of disulphide sulphur—even up to about half or more of the total amount. The rest is sulphidic. Hydrogen sulphide lignin has a high methoxy content. Some of this can be split off by heating to a high temperature in alkali solution. Thus, the low methoxy content of sulphur lignin from a sulphate cook has nothing to do with the sulphurization. It is a reaction by itself.

We have also subjected hydrogen sulphide lignin to methylation and acetylation in the same manner as Brauns and Ahlm. The most apparent difference between Brauns' "native lignin" and hydrogen sulphide lignin is that it does not take up any methoxy groups upon treatment with methanol and hydrogen chloride, whereas "native lignin," of the molecule size Brauns has assumed, takes up two methoxyl groups for every four already in the molecule. In his work, Ahlm also found a decrease in the methylation tendency of sulphur-poor lignin to one half of the value obtained from "native lignin." Thiolignin shows, on the other hand, a high methylation tendency with diazomethane. Ahlm found, in his product, three methylatable groups with diazomethane per Brauns unit. We have found that our hydrogen sulphide lignin, in the same relation, takes up two such groups. Since thiolignin does not contain any mercaptan groups, it consequently must contain a considerable amount of phenolic hydroxyl groups.

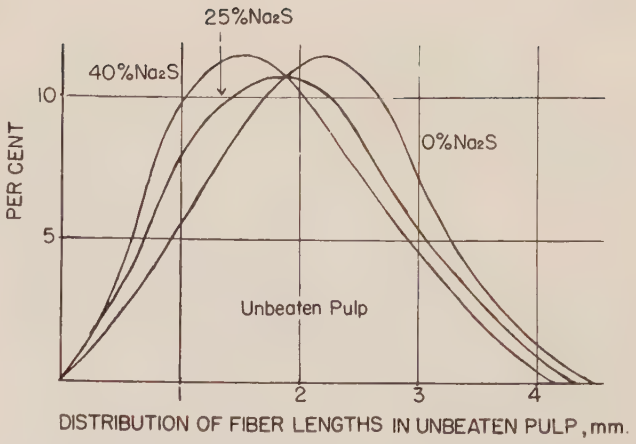


Fig. 4

In the same connection, it was desirable to determine the equivalent weight of thiolignin and to compare it with that of sulphur-free alkali lignin. It has been found possible to find this equivalent weight by potentiometric methods after dissolving the lignin in ethylenediamine. This value has been compared with the value obtained by another method which consists of dissolving the lignin in a definite amount of 0.1 *N* sodium hydroxide. To this is added a barium chloride solution which precipitates the lignin as a salt.

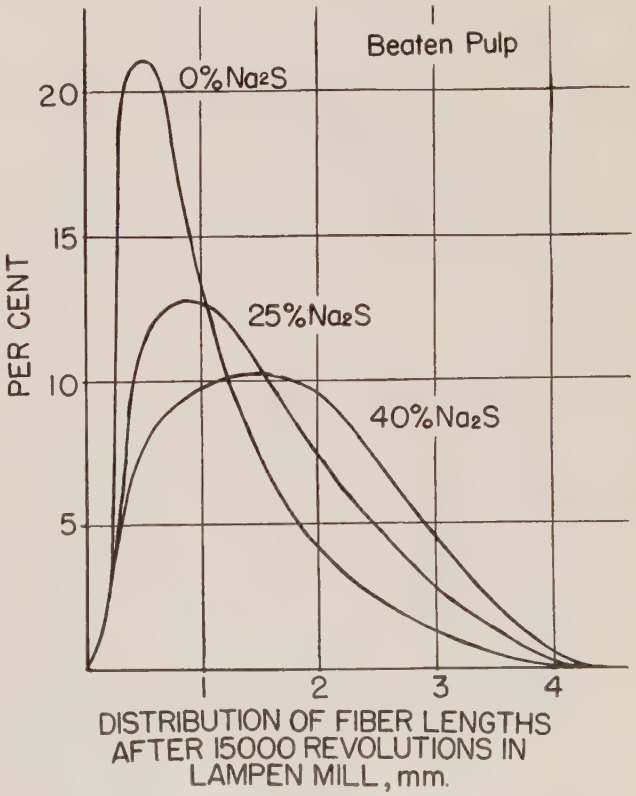


Fig. 5

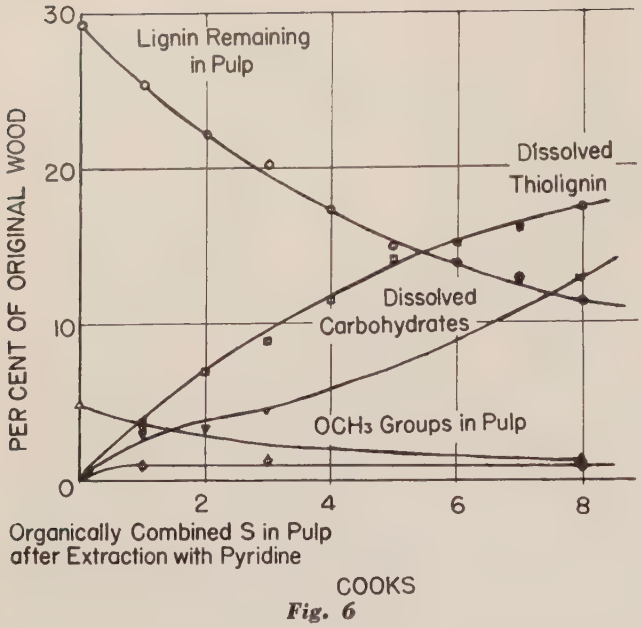


Fig. 6

The amount of unreacted alkali in the filtrate is determined by titration using alpha-naphtholphthalein. The following table shows the values obtained.

It is obvious that both methods show that the equivalent weight for strong alkali cooks is about 200 which corresponds to a lignin building unit of 10 carbon atoms. Hydrogen sulphide lignin, on the other hand, has somewhat higher equivalent weight. It would appear that under these mild conditions not all the phenolic bonds are broken.

It was also of interest to undertake a determination of molecular weight. We have utilized both Rasts well-known method and a method by Hällström which is based on the principle of isothermal distillation.

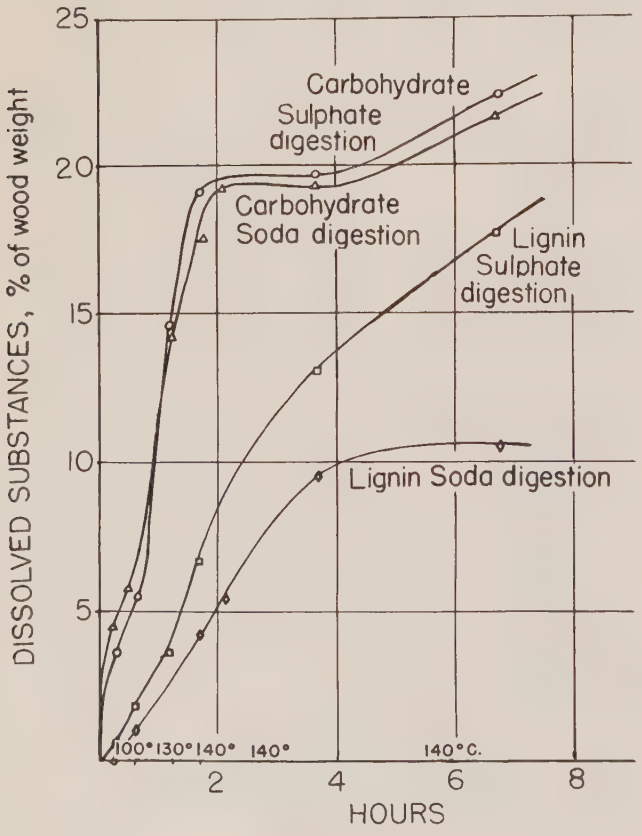


Fig. 7

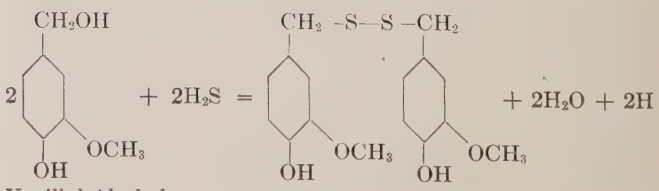
Both of these methods give consistent results. A value of about 1000 was obtained for alcohol-soluble thiolignin. A somewhat higher molecular weight has been observed with alkali lignin, between 1000 and 3000, while ether-soluble hydrogen sulphide lignin, which is obtained in very small amounts, has shown a molecular weight as low as 500. In general, however, thiolignin is to be considered as strongly polymolecular.

We have not obtained by these investigations any solid basis for a belief that isolated thiolignin should be more acid than sulphur-free alkali lignin and the difference in molecular weight, although it exists, is not large enough for one to assume that any essential difference in the rate of diffusion should occur during the cook. The lignin obtained from the "black liquor" of both soda and sulphate cooks shows, to a large extent, similar equivalent and molecular weights. This, nevertheless, does not mean that the lignin cannot behave differently in the two types of cooks during the early phases of the dissolution process. To illustrate this, Fig. 7 shows the dissolution processes of a pure sodium hydroxide cook compared to a sulphate cook of 30% sulphidity. Both cooks were performed on spruce and both had identical alkali ratios and temperature curves. The cook was accomplished at a low temperature, namely 140°C. At different intervals the cooks were interrupted and the contents analyzed. The results shown in Fig. 7 are the amounts of dissolved carbohydrate and lignin in per cent of wood weight.

It is apparent that the amount of carbohydrate dissolved is exactly the same in both types of cooks. The dissolution of lignin in the sulphate cook proceeds relatively unhindered with only a small rate of reaction loss during the entire cooking time, while the pure alkali cook shows, at first, a rapid dissolution of lignin, the same as in the sulphate cook, but then a rapid decrease in rate of reaction after about a third of the lignin has dissolved. If the temperature is decreased to 130°, the reaction decrease occurs after only a fourth of the lignin has gone into solution. The difference in speed of dissolution can thus, in some degree, be equalized by an increase in temperature, a fact that we had discovered earlier.

It would be of value to attempt to find a lignin model upon which we might try out the effect of hydrogen sulphide and sodium sulphide. Such a model, known from the sulphite process, is vanillyl alcohol. It is to be noticed that phenol alcohols, of a similar type, are intermediate products in the synthesis of phenolformaldehyde resins, such as bakelite, and that these phenol alcohols are known to be easily condensed by alkali to high molecular amorphous resins.

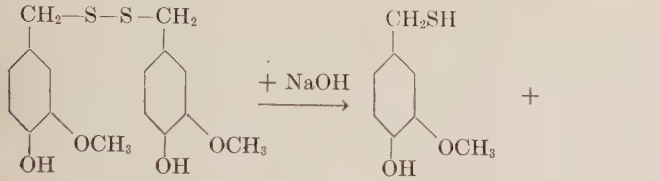
Vanillyl disulphide is obtained in a good yield by treating vanillyl alcohol with hydrogen sulphide at a pH of 7 and 100°C.



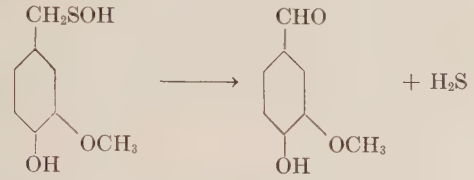
Vanillyl Alcohol — Vanillyl Disulphide

Component soluble in	NaOH 160° 16 hours	Na_2S 160° 3 hours		Lignin obtained by treatment with NaSH 160° 16 hours		H_2S 100° 72 hours			
	Ethanol	Ethanol	Ether	Ethanol	Dioxan	Ether	Ethanol	Ethanol	Ethanol
Sulphur content in lignin, %	0	3.77	3.24	6.16	5.27	12.09	8.82	7.23	8.98
Equivalent weight:									
1. $BaCl_2$ method	190	223	..	238	232	281	..	347	..
2. Ethylenediamine method	200	..	192	260	..	..	372	..	321

It is known from earlier work (Schöberl) that many disulphides are decomposed by heating with alkali to a molecule of sulphenic acid and one molecule of mercaptan.



Vanillyl Mercaptane



Sulphenic Acid Vanilline

The sulphenic acid (in the presence of sodium hydroxide) splits off hydrogen sulphide and gives the corresponding carbonyl compound. Vanillyl disulphide has not been examined before in this respect, but we have found that such a reaction takes place to at least 50% of the disulphide.

It is very possible that carbinol groups connect to the benzene nucleus in the lignin react in a similar manner. In our work we have found that hydrogen sulphide lignin splits off about half its sulphur as hydrogen sulphide. The only difference is that this occurs at a considerably higher temperature than for vanillyl disulphide.

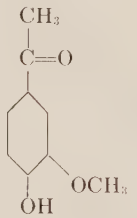
Our investigations of the reactions of hydrogen sulphide on lignin model substances are still being carried on.

Our investigation of the so-called "water-soluble lignin" also deserves mention. The author discovered, 25 years ago, that some of the lignin in black liquor could not be precipitated by acids. This occurs in all types of black liquors from cooks with spruce to an amount of about 7% of the wood weight, that is, about 25% of the amount of lignin. If one cooks with hydrosulphide at 150°, a liquor is obtained from which no lignin can be precipitated by hydrochloric acid. It is all "water soluble." Some of this "water-soluble" lignin precipitates on evaporation in a hydrochloric acid solution or upon the addition of concentrated hydrochloric acid as an amorphous substance, which, after purification, contains 9.4% ash, 11.9% organically bound sulphur, and 7% methoxy groups. Elementary analysis gave the formula.

$$C_9H_{9.3}O_{2.2}S_{0.7}(OCH_3)_{0.4}$$

Thus, the substance is poor in methoxyl and rather rich in sulphur. Its yield amounts to 4% of the wood.

Acetovanillone, and its methylation product, acetoveratrone, are obtained by cooking with sodium hydrosulphide in a yield of about 0.9% by methylation with dimethyl sulphate, ether-extraction, and distillation over a spinning band fractionating column. On the other hand, no aldehydes, such as vanillin or veratric aldehyde, are formed. In ordinary "black liquor" from sulphate mills, acetovanillone is obtained in an amount of only about 0.1% of the wood weight. No acetovanillone can be formed from the "black liquor" from pure alkali cooks. This fact shows again the special function of the sulphide in the sulphate cook.



Acetovanillone

On the basis of our investigations, we have advanced the following hypotheses for understanding the part played by the sulphidity in the sulphate cook.

The first step is that during the sulphate cook, the lignin takes up sulphur in the solid phase. The group in the lignin that reacts in this case is, presumably, the same as that which reacts with alcoholic hydrochloric acid. It is believed that the hydroxyl in substituted benzyl alcohol groups is replaced by a mercaptan group. This is, however, not stable in alkali solution but is converted into a sulphide group by reacting with a hydroxyl group from either the same or another molecule.

The second step, which naturally is closely connected to the first, consists of a hydrolytic splitting under the effect of alkali. In this manner free phenolic hydroxyl groups are formed, and the lignin becomes soluble in alkali. The disulphide compounds, eventually formed by the addition of sulphide to lignin, are split under the influence of alkali to the corresponding mercaptan and sulphenic acid. The hydrogen sulphide which is then split off from this acid can react again with more lignin. The mercaptan, in its turn, is converted to a sulphide by reacting with a hydroxyl group in the same or another lignin residue. It is very probable that the hydrolytic splitting of the phenolic groups takes place much easier if the lignin has first reacted with sulphur.

By means of sulphidization a condensation-sensitive group is blocked, and thus is less inclined to condense in the as yet undissolved lignin. Such a condensation is very possibly the cause for the fact that the lignin remaining in the wood in a sulphide-free alkali cook becomes more difficult to dissolve and thus makes the dissolution of lignin, in general, much slower.

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Thickening Various Latices with Methocel and Other Water-Soluble Materials

L. H. SILVERNAIL

The thickening efficiency of Methocel (15 cp.), Methocel HG (15 cp.), Carboxymethocel-S (low viscosity), Cellosize WSLM, Amberlite W-1, and casein was studied with the following latices: natural latex, Hycar OR-25, GRS-III, Geon 31X, Neoprene Type 571, Chemigum Type 200, and 512-K Latex. It was found that Methocel (15 cp.) had the best thickening efficiency with Geon 31X, Chemigum Type 200, Neoprene Type 571, and 512-K Latex. With these latices, the thickening produced by Methocel (15 cp.) was immediate and was stable over a comparatively long period of time. For Hycar OR-25, it was indicated that Carboxymethocel-S (low viscosity) and Amberlite W-1 had the best thickening efficiency of the agents tested.

THE USE of natural and synthetic latices, both elastic and plastic types, is becoming more and more prevalent in the paper industry. In general, their ability to impart functional properties to paper and paperboard has made them vital raw materials for a great many mills. The range of latex applications includes adhesives, laminated products, impregnated sheets, and surface coatings. The technique of handling and compounding these latex dispersions has raised new problems for papermakers and converters.

The compounding of latices to obtain specific results usually involves a method of viscosity control. In many cases, hydrophylic colloids are being used as thickening agents. The purpose of this work is to compare the effectiveness of Methocel derivatives as thickening materials with the effectiveness of some other commonly known agents.

The complexity and the scope of the materials and variables involved made it impossible to cover the entire field in this report. Additional work will be necessary to complete the study and to keep abreast with new developments. The initial work was done with the low viscosity type material since previous experience indicates that this type gives better stability to thickened dispersions.

EXPERIMENTAL

A concentration of thickener of 0.1 to 5.0% based on latex solids (shown in table of products used) was evaluated. All thickeners were added as 10% aqueous solutions. In each case the latex was added to the thickener. In addition to Methocel (15 cp.) and Methocel HG (15 cp.), such well-known thickeners as Carboxymethocel-S (low viscosity), Cellosize WSLM, Amberlite W-1, and casein were studied.

Viscosity measurements were made by using a Brookfield viscosimeter at 30 r.p.m. (except for viscosities exceeding 20,000 cp.), and at a constant temperature of 75°F. The original viscosities were determined immediately after the samples were prepared and brought to a constant temperature. Subsequent viscosities were checked at intervals over a 30-day standing period in order to determine the stability of the thickened dispersions. At the time of the viscosity determination the samples were checked for any evidence of instability, or incompatibility, indicated by creaming, phasing, coagulation, lumping, etc. Whenever creaming or phasing was observed, a second viscosity was taken after thorough stirring and the second values were used in the viscosity-stability figures.

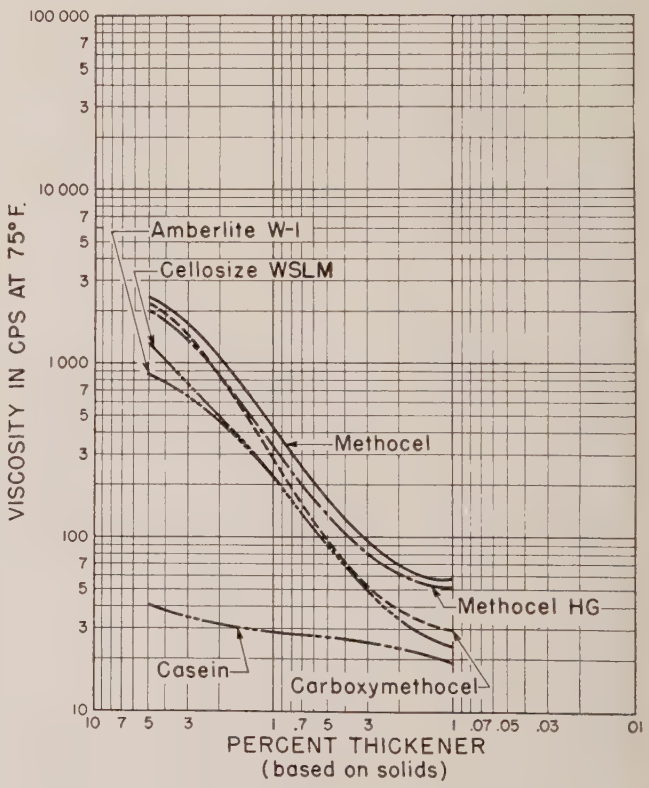

Fig. 1. Normal (natural) latex viscosity curves

It would be well, at this point, to clarify the terms "creaming" and "phasing" as used here. Natural latex, whether it is concentrated or the normal variety, creams on standing. This action causes a concentration of rubber or butter with a low amount of serum in the upper portion, leaving serum with little if any rubber in the lower portion. In the case of some synthetic latices where the specific gravity of the elasto-

L. H. SILVERNAIL, Chemist, The Dow Chemical Co., Cellulose Products Division, Midland, Mich.

mer is greater than that of the serum, the concentration of the polymer particles takes place in the lower portion of the dispersion leaving the serum in the upper portion. This condition will be termed "phasing," and the rising of the elastomer will be referred to as "creaming." In general, the synthetic latices have greater stability than natural latex due, primarily, to

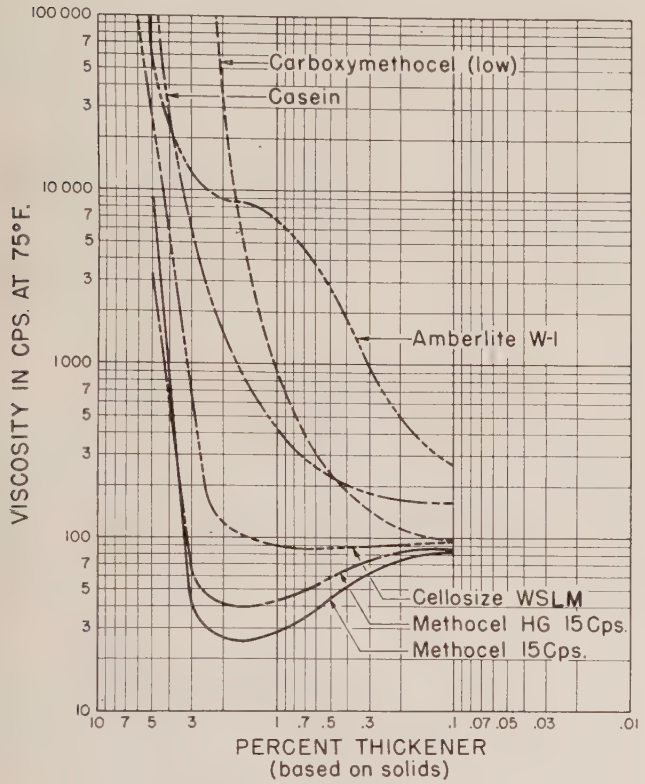

Fig. 2. Goodrich Hycar OR-25 viscosity curves

their smaller particle size and, consequently, are less susceptible to creaming or phasing.

In this study, data on each of the latices have been grouped so that the effectiveness of each of the various thickeners can be easily compared. All viscosity concentration curves were plotted from data obtained at the end of a 1-day standing period.

Natural Latex

In the case of Natural Latex (Fig. 1), Methocel (15 cp.), Methocel HG (15 cp.), and Carboxymethocel-S (low viscosity) have superior thickening efficiency over the other agents tested. Referring to these three thickeners, the Methocel derivatives apparently have an edge over Carboxymethocel-S, particularly in the lower concentration range. Cellosize WSLM showed a lower thickening efficiency than the other cellulose ethers. Amberlite W-1 was about as effective as Cellosize WSLM, and casein resulted in practically no thickening in the concentrations used.

As previously pointed out, natural latex is the easiest of all of the latices to cream. This is due primarily to its comparatively large particle size. In this work, creaming resulted with all of the thickeners tried. The dispersions thickened with Methocel (15 cp.) and Methocel HG (15 cp.) were the most susceptible to creaming. However, it was shown that when the creamed samples were stirred they returned to their original viscosities. Therefore it would seem that creaming, in this particular case, would not be harmful wherever agitation is, or could be, employed.

Hycar OR-25

Hycar OR-25, a butadiene-acrylonitrile—Buna N type (Fig. 2), manufactured by the B. F. Goodrich Chemical Co., gave very unusual thickening curves. The viscosity-concentration curves of Methocel (15 cp.), Methocel HG (15 cp.), and Cellosize WSLM had very marked dips in them. The curves for Amberlite W-1 and Carboxymethocel-S (low viscosity) turned out normally. There was no attempt made to account for these dips, but it was observed that as the polarity of the thickener increases, the dip in the viscosity-concentration curves is less pronounced. For example, Carboxymethocel-S and Amberlite W-1 are representatives of comparatively high polar compounds and their curves are normal. The magnitude of the dips for Cellosize WSLM, Methocel HG (15 cp.), and Methocel (15 cp.) varies inversely to the degree of polarity of these less polar materials.

From the curves, it is indicated that Carboxymethocel-S (low viscosity) and Amberlite W-1 are the most effective thickeners for Hycar OR-25. It should be

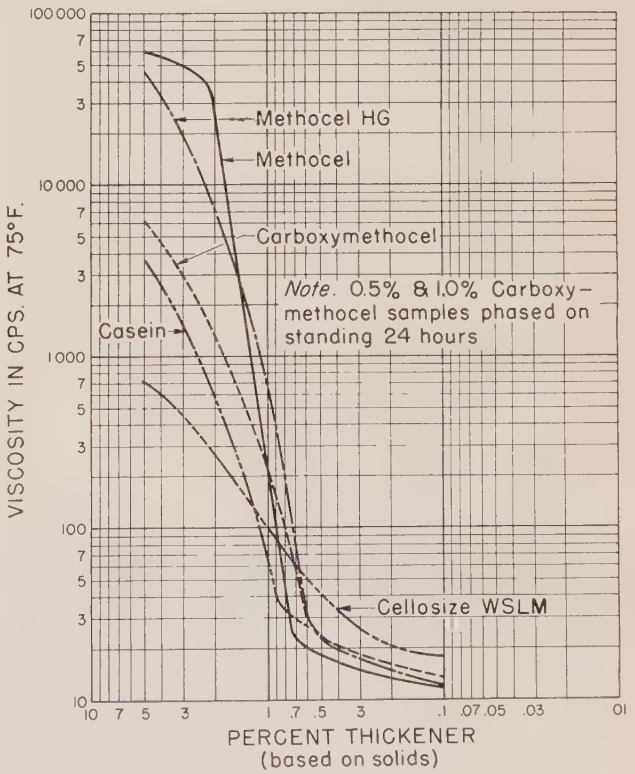

Fig. 3. GR-S type III latex viscosity curves

pointed out that these data are for only one type of the Hycar latices. With other types of Hycar latices and/or higher viscosity thickeners it is possible that other recommendations would be made.

GR-S III

Using GR-S type III, a styrene butadiene copoly-

mer—Buna S type (Fig. 3) purchased from the General Latex and Chemical Corp., very little thickening resulted from any of the thickeners below a concentration of 0.7%. In the low range Cellosize WSLM and Carboxymethocel-S (low viscosity) were the most effective. Although Methocel (15 cp.) was not effective below a concentration of 1.0%, it was the most effective thickener in the high range. At 5.0% thickener concentration the thickeners in order of their effectiveness are Methocel (15 cp.), Methocel HG (15 cp.), Carboxymethocel-S (low viscosity), casein, and Cellosize WSLM.

Geon 31X

Using Geon 31X, a polyvinyl chloride type (Fig. 4), manufactured by the B. F. Goodrich Chemical

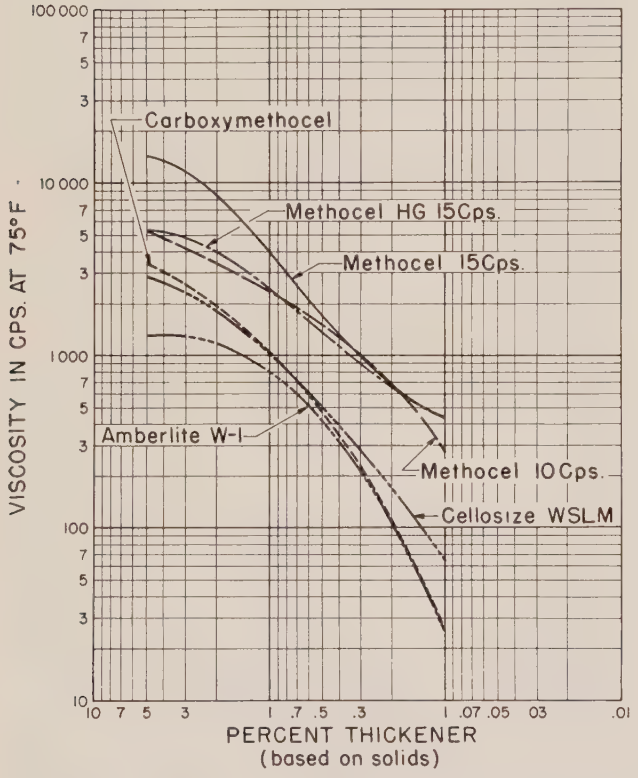

Fig. 4. Goodrich Geon latex 31X viscosity curves

Co., it was found that Methocel (15 cp.) had the highest thickening efficiency of all of the agents tested. The resulting dispersions were smooth and showed no evidence of creaming or phasing. Methocel HG (15 cp.) and Methocel (10 cp.) were next in order of effectiveness. The use of Methocel (15 cp.) gave such high viscosities that Methocel (10 cp.) was also evaluated in an attempt to obtain viscosity values in a lower range. Carboxymethocel-S (low viscosity) and Cellosize WSLM were about equal in effectiveness, and Amberlite W-1 was the least effective. Again casein resulted in pronounced, but unpredictable and varied thickening.

From these data it is concluded Methocel (15 cp.) had the highest thickening efficiency of all of the agents tested.

The Methocel (15 cp.) thickened dispersions were also the most stable and showed the least tendency to phase or to settle out. In fact Methocel and Methocel HG thickened dispersions showed no signs of settling until after 18 days of storage. Even then, there was no perceptible separation but settling was indicated by a viscosity differential between the top and the

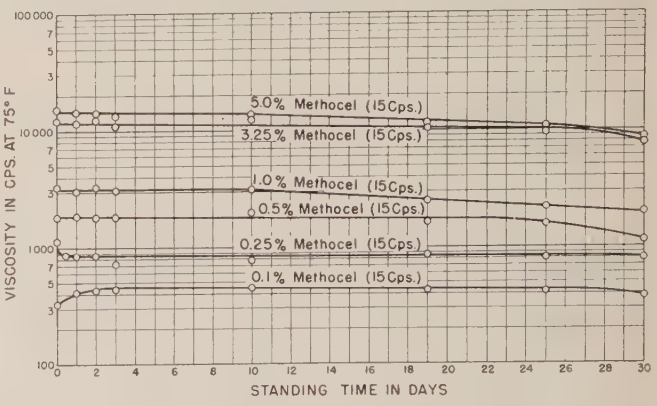

Fig. 4A. Geon 31X thickened with Methocel viscosity stability curves

bottom of the samples. In contrast, the Carboxymethocel-S (low viscosity), Cellosize WSLM, Amberlite W-1, and casein samples started to settle during the initial 24 hours of the storage period.

The exceptional viscosity stability of the Methocel thickened dispersions is shown in Fig. 4A. It should

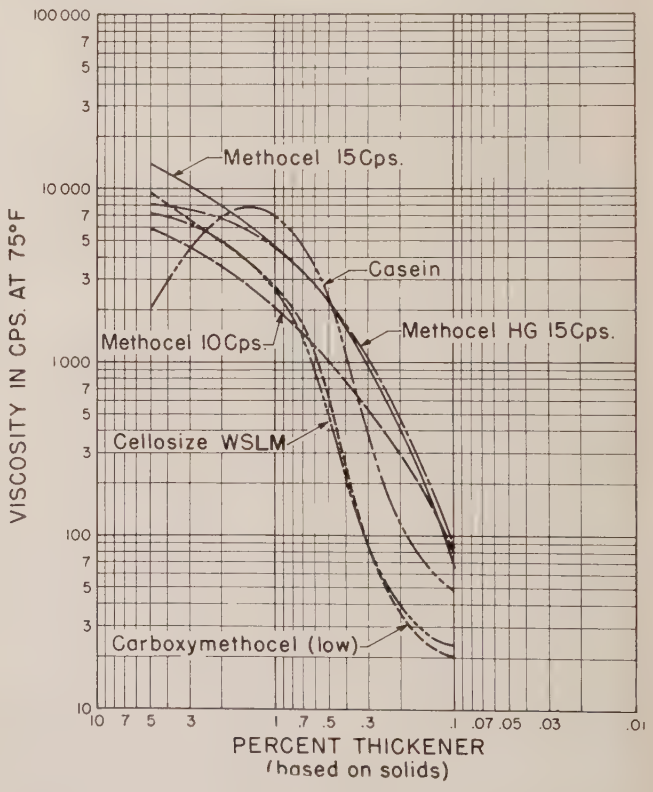

Fig. 5. Dupont Neoprene 571 viscosity curves

be noted that there was practically no change in viscosity during or at the end of a 30-day standing time. It is also shown that when Methocel solution is mixed with this latex, pronounced thickening results at once and is maintained over a comparatively long

period of time. This is almost ideal performance from a practical and operational viewpoint.

Neoprene Type 571

With Neoprene Type 571, a polymerized chloroprene

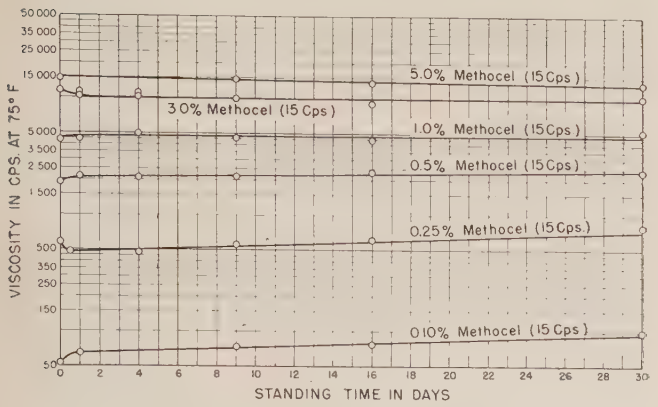

Fig. 5A. Neoprene 571 thickened with Methocel viscosity stability curves

(Fig. 5), manufactured by du Pont, Methocel (15 cp.) had the highest thickening efficiency of all of the thickeners tried. As with Geon 31X, the thickening was considerable and immediate. Figure 5A demonstrates the viscosity stability which can be expected

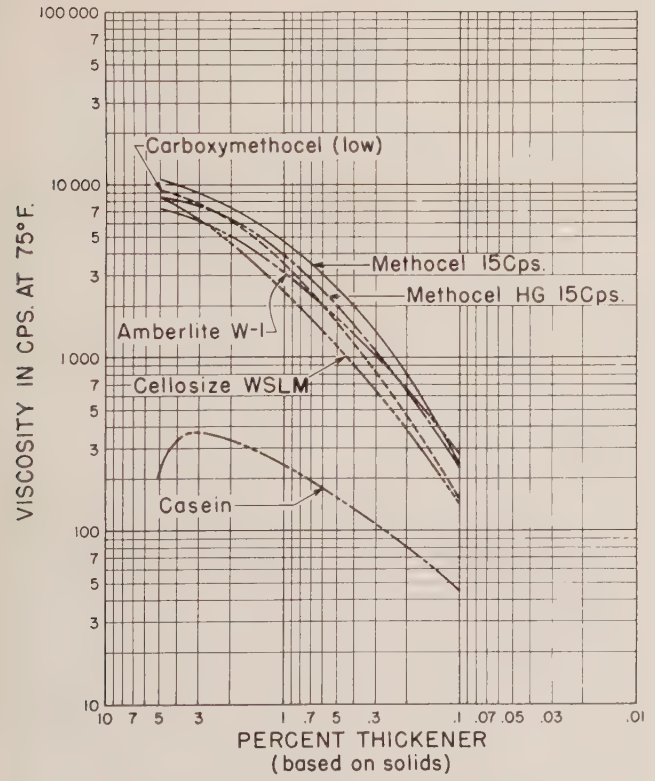

Fig. 6. Goodyear Chemigum latex 200 viscosity curves

from dispersions of Neoprene Type 571 thickened with Methocel (15 cp.).

The dispersions thickened with Methocel (15 cp.) and Methocel HG (15 cp.) showed no tendency to phase on standing 30 days. Samples thickened with Carboxymethocel-S (low viscosity) and Cellosize WSLM started to phase in 24 hours. When Amberlite W-1 was added to this latex, the elastomer precipitated in a rubbery mass.

Chemigum Type 200

When Chemigum Type 200, Butadiene acrylonitrile —Buna N type (Fig. 6), manufactured by the Goodyear Tire and Rubber Co. was used, Methocel (15 cp.), Methocel HG (15 cp.), and Carboxymethocel-S (low viscosity) showed superior thickening over the other agents, with Methocel (15 cp.) having a slight edge over the other two preferred thickeners. Amberlite W-1 showed excellent thickening efficiency at low concentrations but it did not reach the efficiency of the cellulose ethers at the higher concentrations. Again, casein showed only varied, unpredictable thickening.

The dispersions of Chemigum Type 200 showed remarkable stability. None of the samples creamed until after ten days of standing time. At that time there was no visible evidence of creaming, but vis-

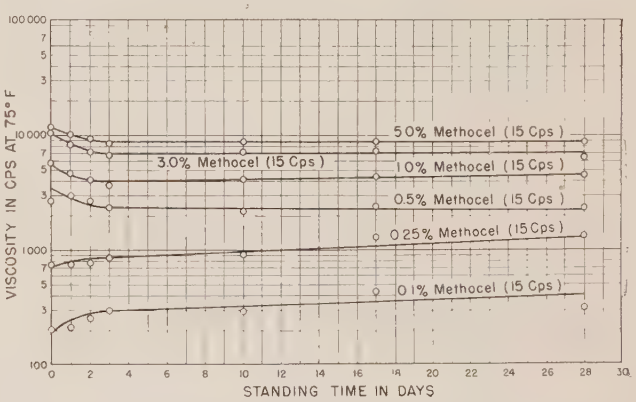
VISCOSITY IN CPS AT 75° F
STANDING TIME IN DAYS
5.0% Methocel (15 Cps)
3.0% Methocel (15 Cps)
1.0% Methocel (15 Cps)
0.5% Methocel (15 Cps)
0.25% Methocel (15 Cps)
0.1% Methocel (15 Cps)

Fig. 6A. Chemigum 101 thickened with Methocel viscosity stability curves

cosity determinations showed a higher concentration of the elastomer in the upper portion of the sample than in the lower portion.

The Chemigum Type 200 dispersions, thickened with Methocel (15 cp.) showed good viscosity stability (Fig. 6A). It is noted that the thickening took place immediately and was fairly constant over a 30-day standing period. There was some tendency for the thinner samples to increase in viscosity and for the thicker ones to decrease on standing, but this tendency was apparently too slight to be significant.

512 Latex

Using 512-K Latex (Fig. 7), a high styrene-butadiene copolymer type, manufactured by The Dow Chemical Company, Methocel HG (15 cp.) showed the highest thickening efficiency. Methocel (15 cp.) and Carboxymethocel-S (low viscosity) were nearly equal in effectiveness with a slight advantage for Methocel. The remaining thickeners in order of their effectiveness are Cellosize WSLM, Amberlite W-1, and casein.

This latex showed extraordinarily fine stability. There were no signs of creaming observed until after standing for 21 days at which time the rise of elastomer was shown by a differential in viscosity between the top and the bottom of the samples.

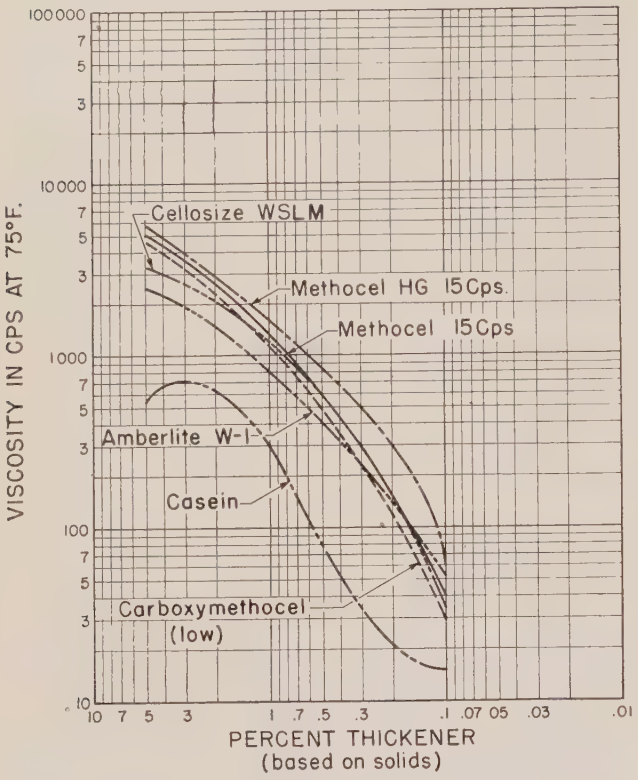

Fig. 7. Dow 512K latex viscosity curves

The viscosity stability (Fig. 7A) of the Methocel (15 cp.) thickened dispersions was very good. The full thickening was effective immediately and practically uniform over a 30-day period. There was a

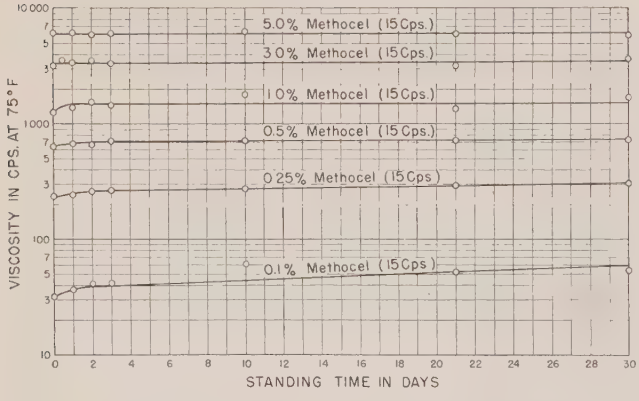

Fig. 7A. Dow 512K latex thickened with Methocel viscosity stability curves

slight tendency for dispersions in the lower range to gain in viscosity. Actually, as was pointed out in the case of Chemigum Type 200, this trend was too slight to be of practical importance.

CONCLUSIONS

As pointed out earlier, this study covers only a limited number of latices. However, an attempt has been made to develop enough data to give a worker in this field a base point from which to start.

The present applications of latices in the paper industry are varied and differ widely in purpose and in compounding requirements. Examples of applications showing this diversity are: (1) service papers for greaseproofness, solvent resistance, low moisture vapor transmission, (2) nonslip rug backings, (3) waterproof adhesives, (4) heat-sealable coatings, (5) artificial leather, (6) paper tablecloths, drapes, and towels, and (7) masking tape-pressure sensitive adhesives.

It is obvious that each of these applications presents different problems. The development of new products is bound to necessitate the innovation of new methods of compounding.

Present plans include further evaluation of Methocel derivatives as thickeners and stabilizers as applied to the present uses of latices in the paper industry. In addition, continuing effort will be made to keep abreast with new developments in this field.

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2. Methocel HG, modified methylcellulose, The Dow Chemical Co., Midland, Mich.
3. Carboxymethocel-S, sodium salt of carboxymethylcellulose, The Dow Chemical Co., Midland, Mich.
4. Amberlite W-1, a water-soluble polyacrylate, Resinous Products and Chemical Co., Philadelphia 5, Pa.
5. Cellosize WSLM, hydroxethyl cellulose, Carbide and Carbon Chemicals Corp., New York 17, N. Y.
6. Casein (papermakers), Casein Company of America, 350 Madison Ave., New York 17, N. Y.
7. Natural latex (39% solids), General Latex & Chemical Corp., 666 Main St., Cambridge, Mass.
8. GR-S III latex (40% solids), General Latex & Chemical Corp., 666 Main St., Cambridge, Mass.
9. Geon 31X (50.4% solids), B. F. Goodrich Chemical Co., Rose Bldg., Cleveland 15, Ohio.
10. Hycar OR-25 (41.0% solids), B. F. Goodrich Chemical Co., Rose Bldg., Cleveland 15, Ohio.
11. Chemigum Type 200 (51.2% solids), Goodyear Tire & Rubber Co., Akron, Ohio.
12. Latex 512-K (45% solids), The Dow Chemical Co., Midland, Mich.
13. Neoprene Type 571 (50.2% solids), E. I. du Pont de Nemours & Co., Wilmington, Del.

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Determination of the Suitability of Wood Pulp for Acetylation

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Among the various methods for determining the suitability of a wood pulp for acetylation and other conversion purposes are those which are concerned with the completeness of reaction. Whereas cotton linters, when acetylated with a mixture of acetic anhydride and glacial acetic acid, with sulphuric acid as a catalyst, give a colorless, clear, and fiber-free solution, wood pulps, in general, produce hazy solutions of a more or less yellowish tinge; such solutions also contain poorly dispersed portions—i.e., highly swollen "lumps" of a colloidal nature and incompletely acetylated or even unacetylated fibers.

It is this incompleteness of reaction which causes difficulties in the use of wood pulp instead of cotton linters for conversion purposes. These difficulties are less pronounced with sulphite pulps, even in their unrefined (unpurified) state, than with sulphate pulps. The latter pulps may not be used at all, and alkaline refining does not improve the situation. However, they may be used when prepared from acid-prehydrolyzed wood chips or by modifications of such procedures, as was shown during the war by some European pulp mills; this was recently the subject of an interesting laboratory study by McKinney (*1*).

Although the substitution of highly alkaline-refined sulphite pulp for cotton linters has made considerable progress during the war years, attempts to prepare wood pulps suitable for conversion purposes have by no means reached perfection.

Jayme and Schenck (*2*) suggested a method by which not only the undissolved material present in a primary acetate solution but also the haziness (turbidity) may be determined by quantitative procedures.

The acetylation procedure used by Jayme and Schenck is carried out in relatively high dilution in order to eliminate irregularities which easily occur in a more concentrated and viscous system. The greater dilution also allows more exact temperature control and results in good reproducibility.

Before the cellulosic material to be investigated is subjected to the acetylation procedure proper, it undergoes a pretreatment with glacial acetic acid at 90°C. for 3 hours. According to Jayme (*3*), this treatment eliminates differences in reactivity (i.e., rate of acetylation), differences which depend essentially upon such factors as the use of cold and strong or hot and weak alkali in the refining step and the manner in which and the temperature at which the refined pulps are dried. The elimination of reactivity differences in the acetylation procedure is deemed desirable, because such differences would interfere with a technique which is intended to ascertain the influence exerted by the chemical purity of the pulp.

After removal of the pretreatment solution and subsequent washing with glacial acetic acid, which removes the majority of the contaminating resins, fats, and coloring matter from the pulp, the fibers are again submerged in glacial acetic acid and allowed to stand in a closed vessel overnight at 20°C., after which more glacial acetic acid, containing a certain quantity of concentrated sulphuric acid, is added with subsequent stirring and cooling so as to maintain a temperature of 18°C. When the suspension appears well mixed, actual acetylation is started by adding the necessary amount of acetic anhydride at such a rate that the temperature remains between 18 and 20°C., after which the temperature is allowed to rise to 35°C. and the mixture is kept at this temperature for 5 hours.

The solution is cooled to room temperature and subjected to turbidity measurements by means of a Pulfrich photometer, the first measurement being made with the cooled solution immediately and the second after the solution has been centrifuged several times—i.e., until the turbidity has become practically constant. The solid residue which remains at the bottom of the tube after centrifuging consists essentially of fibrous matter and that (very small) portion of the turbidity-causing material which, by virtue of its particle size, still lends itself to removal by centrifuging. The solid residue is separated from the supernatant liquor, thoroughly washed with glacial acetic acid and subsequently with water, dried, and weighed.

The degree of turbidity for a given pulp is expressed by relating its final turbidity value (i.e., after centrifuging) to that of cotton linters which serves as a standard.

The turbidity and insoluble residue values obtained by Jayme and Schenck for cotton linters and two pulps are listed in Table I.

The data show that the turbidity of the refined pulp was 8.8 times and that of the unrefined pulp 15.2 times greater than that of cotton linters and that the insoluble residues also revealed characteristic differences.

In the present study, Jayme and Schenck's method

Table I. Turbidity and Insoluble Residue Values for Cotton Linters and Wood Pulps (Jayme and Schenck)

	Cotton linters	*Hot-alkaline refined sulphite pulp*	*Unrefined sulphite pulp*
Turbidity, %[a]	100	880	1520
Insoluble residue, %[b]	0.15	0.38	10.24

[a] On basis of cotton linters value.
[b] On basis of original material.

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of acetylation was followed with slight modifications. However, instead of the Pulfrich photometer, which is rather widely used in European laboratories but not in this country, the transparency meter based on the work of Wicker (*4*) [cf. (*5*)] developed by the Physics Staff of the Institute for the testing of tinted glassine paper (*6*) was used.

It was found that this instrument served the particular purpose quite adequately and would seem to have some advantages over the Pulfrich instrument.

The suitability of the transparency meter was demonstrated with two widely different commercial pulps—one was a highly refined sulphite pulp manufactured for acetylation and other conversion purposes and the other was an unbleached Mitscherlich pulp representative of a pulp material not suitable for acetylation. Commercial cotton linters served as a standard.

Some of the chemical and physical characteristics of these cellulosic materials are shown in Table II. They would seem to be those generally observed for cotton linters and these types of pulps.

The amount of cellulosic material employed in the present study was 20 grams in each case. In the pretreatment step, the material was submerged in 500 grams of glacial acetic acid (in a glass beaker), placed on a steam bath, and kept at 90°C. for 5 hours. The cooled mixture was filtered on a Buchner funnel until the pulp retained 100 grams of glacial acetic acid. The subsequent procedures were essentially as employed by Jayme and Schenck, the additional amount of glacial acetic acid being 400 grams, containing 4 grams of sulphuric acid (calculated as 100% H_2SO_4). The acetic anhydride, added through a funnel attached to the reaction vessel (a closed glass jar), amounted to 150 grams.

Table II. Chemical Characteristics of Cellulosic Materials Used for Acetylation

	Alpha-cellulose, %	*Pentosans, %*	*Copper number*	*Ash, %*	*TAPPI Viscosity, centipoises*	*Nitrate D.P.*[a]
Cotton linters	98.3	...	0.06	0.13	124	1440
Conversion pulp[b]	93.4	1.4	0.69	0.20	30.6	1145
Unbleached Mitscherlich pulp[c]	84.8	4.9	...	0.70	...	1800

[a] Degree of polymerization derived from specific viscosity measurements on the nitrate dissolved in acetone, using the Staudinger function.
[b] Resin, 0.3 %.
[c] Lignin, 1.3 %.

The solution was cooled to 20°C. and thoroughly mixed by mechanical stirring; its volume was measured in a graduate cylinder. Portions of it were subjected to turbidity measurements (initial value). Additional portions of 80 ml. each were poured into a 100-ml. cone-shaped centrifuge flask and centrifuged at 2000 r.p.m. for 15 minutes in an International Equipment Co. centrifuge. Aliquot portions of the more or less hazy supernatant solution were again subjected to turbidity measurements (final value). It was found that 15 minutes of centrifuging sufficed to give a practically constant turbidity value.

The insoluble residue, which had collected at the bottom of the centrifuge flask, was separated from the remaining supernatant solution, thoroughly washed with glacial acetic acid, dried, and weighed. The amount thus found for the aliquot part of the solution was calculated for the total volume (630 ml). In order to relate the weight of the recovered material to that of the cellulose originally employed, it was necessary to make a correction for the weight increase caused by the acetyl content of the residue. According to Jayme and Schenck, the acetyl content may be quite substantial and may even approach that of the triacetate. It is probable that the insoluble material is composed chiefly of acetylated noncellulosic carbohydrates (for example, xylan acetate), which are insoluble in glacial acetic acid and may influence the solubility of the acetylated cellulose, regardless of the degree of acetylation.

The acetyl content of the residue was determined by the modified Eberstadt method (*7*).

As mentioned earlier, the turbidity measurements were carried out with the transparency meter. Essentially, the optical system of this instrument consists of a source of light, a condensing lens which forms a parallel beam of light, a pair of circular apertures, and a photocell. The beam of light passes axially through the apertures, the first of which (No. 1) is near the condensing lens and the second of which (No. 2) is remote from the first aperture and immediately in front of the photocell.

Two measurements of transmission of the acetylation solution are made. The first, designated "parallel transmission" (P.T.), is made with the cell adjacent to aperture No. 1. The second measurement, designated "total transmission" (T.T.), is made with the cell between aperture No. 2 and the photocell. A cylindrical tube between the two apertures is lined with a light-absorbing surface and serves to absorb scattered light. The "transparency ratio" (T.R.), which is the quantity (in per cent) employed in the measurement of turbidity, is obtained through the following equation:

$$(\text{T.R.}) = 100\ (\text{P.T.}/\text{T.T.})$$

For the present purposes, turbidity is defined by the equation:

$$\text{Turbidity} = 100 - (\text{T.R.})$$

The parallel transmission is, of course, the quantity more sensitive to optical scattering. If measured alone, however, the observed result would be a function of absorption of light due to color as well as to optical scattering. By the use of the ratio of parallel to total transmission, the influence of color (through light absorption) is nearly eliminated, so that the transparency ratio is almost purely a function of light scattering resulting from the presence of suspended particles.

A blank test showed that the acetylation mixture itself (i.e., a mixture of glacial acetic acid, acetic anhydride, and sulphuric acid) is not a haze-contributing factor.

The solutions of the various cellulosic materials were colorless in the cases of the cotton linters and the conversion pulp, whereas the unbleached Mitscherlich pulp produced a distinctly brown color, not only in the pretreatment operation but also in the acetylation solution.

The data obtained for turbidity and insoluble residue are listed in Table III. Distilled water served as a blank.

Table III. Transmission Values and Insoluble Residues for Cotton Linters and Sulphite Pulps

	P.T.	*T.T.*	*T.R.*	*Turbidity*	*Suitability number*	*Insoluble residue, %*
Cotton linters						
Initial values	90.2	91.8	98.3	1.7	59	No measurable amounts
Final values	91.2	92.0	99.2	0.8	...	
Conversion pulp						
Initial values	81.0	88.0	92.0	8.0	13	0.1[a]
Final values	83.5	88.8	94.1	5.9	...	
Unbleached Mitscherlich pulp						
Initial values	20.2	1.3	6.4	93.6	1.1	28.6[b]
Final values	15.0	38.0	39.4	60.6	...	...
Distilled water	91.5	92.0	99.5	0.5	...	...

[a] An acetyl content of 40 % was assumed.
[b] Acetyl content actually determined was 40.2 %.

The data show that the transparency was highest (and the turbidity lowest) for the cotton linters, closely approaching the values for distilled water, and that the conversion pulp gave values approximating those for cotton linters. In contrast, the transparency was very poor for the unbleached Mitscherlich pulp.

It is also seen that the insoluble residue was not measurable in the case of the cotton linters, that it was almost negligible for the conversion pulp, but that it was very high for the Mitscherlich pulp. This difference in insoluble residue for the two pulps is reflected, of course, in the differences in their turbidity before and after centrifuging. The comparison shows that, in order to arrive at the true turbidity values, centrifuging is the more necessary the greater the insoluble residue.

The results obtained with the use of the transparency meter would seem to show that it is well suited for measuring the turbidity of acetylation solutions obtained from various cellulosic materials.

The turbidity results may also be expressed in a different way. By dividing the initial turbidity into an arbitrary constant—e.g., 100—a value is obtained which may be termed "suitability number." This number is a measure of both turbidity and insoluble residue. If this is done for the two pulps, the conversion pulp would have a suitability number of 13, whereas that for the unbleached Mitscherlich pulp would be only 1.1.

The use of the suitability number would possibly eliminate the necessity of determining the insoluble residue and thus the only measurement necessary would be that of the initial transmission values.

The application of the Jayme and Schenck method, in combination with the use of the transparency meter, to a greater number of refined pulps will show whether the differences in turbidity and insoluble residue or in suitability numbers are great enough to be of practical value in predicting the commercial suitability of such pulps.

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Statistical Control of Paper Quality

I. Basis Weight and Moisture Content

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In a sulphite bond and specialty mill, modest but encouraging progress has been made toward the statistical control of basis weight and moisture content. Over a period of three months' operation on one machine, Shewhart control charts have been applied with some success to all runs which were 15 hours or more in duration. Three advantages in the use of the control charts have immediately become evident: First, the charts have illustrated clearly the effect of basis weight fluctuation on uniformity of moisture content—a relationship which the operators had taken for granted, but which the supervisory personnel had not fully appreciated. Second, the charts have helped to emphasize the undesirable effects of equipment deficiencies whose influence had been known perhaps qualitatively but not quantitatively. Third, on most paper machines, the skill and judgment of the operators are the final factors which determine how uniform the basis weight and moisture will be. The control charts contribute to this skill because they replace the operators' intuition, and the arbitrary tolerances which are so often established, with practical, realistic limits based upon past performance of the same machine. These limits can eliminate most of the guesswork from basis weight and moisture control. In spite of these advantages, the operators have been rather slow to utilize fully the information which the control charts provide. This apparently is not due to any unwillingness on their part to cooperate, but rather to their lack of complete understanding and appreciation of this new tool which has been offered to them. The need for further cooperative efforts on the part of the supervisory personnel is therefore indicated.

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It is the purpose of this paper to give a progress report on the use of Shewhart charts in the control of paper quality. The underlying statistical theory has been described so well by Shewhart himself (*1*), and more recently by Grant (*2*), Catlin (*3*), and Bicking

(*4, 5*), that the present writers will make no attempt to defend their procedures from a scientific point of view. Rather it is their hope that a step-by-step account of their experiences in adapting the procedures to fit the needs of one fairly typical sulphite bond mill may provide help and encouragement to those who may be contemplating a similar course of action.

The Shewhart charts were developed and first applied in an industry where it is possible to sample the product with ease at almost any instant and at various stages of manufacture. Not only in this respect, but in other important ones, the paper industry is fundamentally different. It is to be expected, therefore, that the charting procedures as originally developed will not be altogether applicable to paper manufacture, and that some revisions will be necessary.

No one has yet discovered a way to sample the production of a paper machine without interrupting the continuity of the sheet. Depending on the caliper of the grade in question, this means that a satisfactory sample can be taken all the way across the width of the sheet at intervals of roughly every 30,000 feet in the machine direction; if the machine crew is not too busy with other duties, perhaps the reel can be turned up and sampled twice as often, or every 15,000 feet. This means that any control procedure must utilize to the fullest extent possible all the information which can be obtained from these reel samples. It is true that the backtender does tear out weigh sheets whenever he can do so without making necessary an extra splice. These weigh sheets, however, do not represent the production at the instant of sampling nearly as well as the reel samples do. Unless he makes due allowance for their inherently greater variability, it can easily happen that the machine tender will be led to over-correct, and hence defeat the very purpose for which the weigh sheets were taken. In general, then, papermaking is a process in which a reliable sample is obtained at regular but infrequent intervals.

If the driver of an automobile is blindfolded and told only once every 6 miles whether he was approaching the edge of the pavement, he could hardly be expected to stay on the highway, yet by analogy, that is just about what the papermaker is asked to do. Strangely enough, however, he can do a fairly good job at it once the machine is properly adjusted for a given weight and grade. His success depends largely on his ability to interpret the data obtained from the reel samples, particularly those taken near the beginning of the run. In examples of statistical quality control frequently cited it is considered an evidence of "trouble" whenever a point goes outside the control limits. The trouble is usually of such a nature that the operator is supposed to report it to his supervisor, who in turn calls in the plant engineer, etc. In paper manufacture, the "trouble" is so continuous that the operator has to live with it constantly; he is not expected to report it to anybody, but only to correct it by an appropriate adjustment of his gate box, jordan setting, or drying temperature.

Some paper machines have elaborate automatic devices for control of basis weight and moisture. By far the majority, however, are essentially hand-controlled, and the skill of the operators is an integral part of them. Any control program such as the one discussed in this paper must take into consideration at all times the operator's attitude; if he does not see fit to use the information and the tools made available to him, the program will be a failure. The paper testers are also concerned for their promptness and accuracy in making the information available will determine how much defective paper is made before corrective action can be taken. The supervisors must be sympathetic and must have a general understanding of the procedures involved. Finally, as someone has wisely said, the program must have the approval of management for the condition and production of a mill can be no more than a reflection of what the boss desires.

The scope of this article is limited to a discussion of experience in the control of basis weight and moisture content. The charts have been applied with some success to other qualities as well, but the most intensive work in this mill has been with the two mentioned. This is natural enough when it is recognized that uniformity of basis weight and moisture content must be achieved before any other paper quality can be brought into control.

DETAILED ACCOUNT OF TEST RUNS

In behalf of those readers who may be primarily interested in how the charts actually contribute to quality control, the charting experience for three typical runs will now be described. For those who may be less familiar with Shewhart control charts in general, it may be advantageous to pass over this section rather quickly for the time being, and proceed to the next, which explains in some detail the method used in setting up the control limits, and the rules to be followed in continuous charting at the head of the paper machine.

Figure 1 is a typical basis weight and moisture chart showing two runs of the same weight and grade, made after the program had been in effect for about six weeks. The first of the two runs includes all points to the left of the vertical dotted line. At the time of this run, a combination of operating misfortunes had left the machine with a stock pump in bad repair and with a fourdrinier wire which was badly ridged in the machine direction. The defective pump caused surges in the stock flow at short intervals and hence a rapid variation of basis weight in the machine direction; the ridged wire caused local variations of basis weight in the cross direction. It was not considered feasible to repair the pump or replace the wire until the week-end shutdown.

Shortly after the run had begun the backtender demonstrated to one of the writers that it would be necessary to carry the drying temperature higher than normal; lowering the temperature for even a minute or two caused streaks of calender blackening to appear in the sheet corresponding to the known positions of the ridges and valleys in the wire. The streaks were not continuous; they would appear and disappear at about the same frequency as the surges in the stock pump delivery. After this demonstration, the drying temperature was raised to the point where the calender blackening was no longer noticeable and maintained at that point for several hours. As each succeeding shift

came on duty, however, the backtender was asked to repeat the experiment of lowering the drying temperature. The arrows shown on the moisture chart of Fig. 1 after reel numbers 56, 60, and 61 represent occasions where it was possible to make a permanent decrease in the temperature. It can be seen that in each case there was a corresponding increase in the moisture content of the following reel sample.

The upper half of each basis weight and moisture chart follows the trend from each individual reel to the next. The lower half of the chart is designated "four-average," because each point represents the average of that particular reel and the three immediately preceding. In accordance with statistical theory, the limits for the four-average chart are exactly half as far from the center line as are the limits for individual reels. One advantage of the four-average chart is its

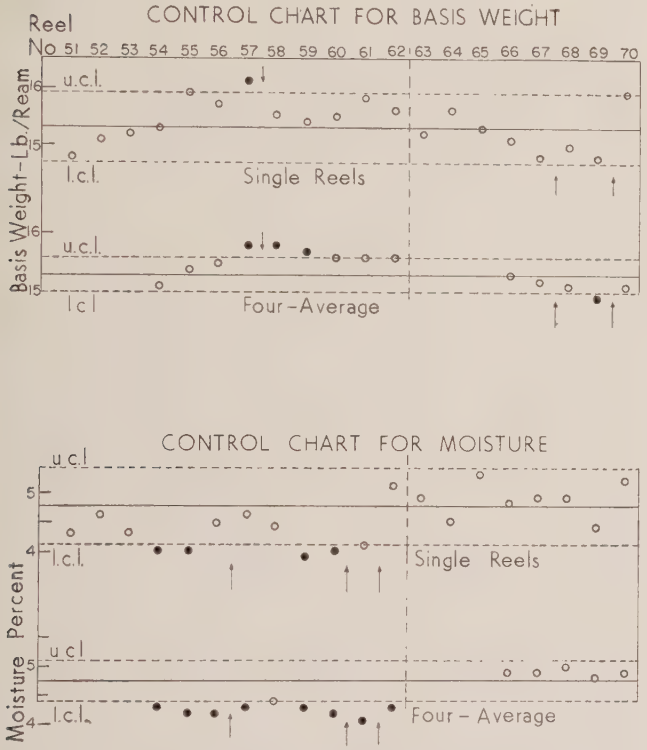

Fig. 1. Two consecutive runs illustrating favorable and unfavorable machine conditions, respectively

greater sensitivity shown very well in the moisture plot for this first run; whereas on the chart for single reels only four points out of twelve were out of control, on the four-average chart *all* the points were shown to be out of control. Other advantages of this method of charting will be mentioned later on.

On the following Sunday, the defective pump was repaired and the fourdrinier wire was replaced. Two days later, another run of the same weight and grade was made, the points for which are shown to the right of the vertical dotted line in Fig. 1. Supplementing the observation of the machine crews that there was less surging of the stock on the wire and that it was possible to build a reel of uniform hardness and free of corrugations, the moisture charts for this run show perfect control, in other words, it was possible to carry the desired moisture content at all times without calender blackening. Since no other production factor was changed between the two runs, it can be accepted as a practical conclusion that the cross-machine variation of basis weight must be small, and the short-term variation of basis weight in the machine direction must also be limited if an average moisture content of 4.75% is to be maintained in this grade.

Although it is often possible to obtain agreement on such a conclusion at the time a run is in progress, the memory of all concerned is apt to be dim when a similar set of circumstances arises at some later date. Charts such as those shown in Fig. 1 can then serve as a very useful reminder of what has occurred in the past and can very often help to prevent an unnecessary repetition of operating difficulties.

With further reference to Fig. 1 it is also apparent that the four-average charts for moisture convey a clearer picture than do the single-reel charts of the difference between the two runs with respect to the general level of moisture content.

The arrows on the basis weight charts show when the machine tender made an adjustment at the gate box. In the first run, where only one adjustment was made (after reel 57), the response was normal. The individual reel chart showed an abrupt change and the four-average chart a gradual change in the desired direction. In the second run, two upward adjustments were made. The first adjustment had only a minor effect which failed to keep the four-average point from going out of control two reels later, the second was almost too great in its effect and might have put the basis weight out of control on the high side if the run had continued longer.

This apparent delay in the response to a basis weight correction is a fairly common experience, so common, in fact, that it has almost been catalogued as one of the insoluble mysteries of papermaking. It is suggested, however, that the machine tenders could let the control charts serve as a useful record of the corrections which they have made. A frequent repetition of the pattern described here would provide the stimulus needed to find and correct the mechanical difficulty whatever it may be. It must be emphasized that charts on finished production, such as these, usually do not of themselves tell what the difficulty is, they merely record when and in what respect a process is out of control.

Figure 2 describes a third run of the same grade but in a lower basis weight. Perhaps the first observation which should be made is the striking similarity in behavior, as shown on the single-reel charts, between the basis weight and the moisture content for the first five reel samples. A further similarity can be seen between the four-average charts for weight and for moisture. It will be recalled that the discussion of Fig. 1 mentioned a recurrence of calender blackening at the same frequency as certain short-term basis weight fluctuations. All these observations merely serve to confirm the experience of the operators who have often remarked that the temperature and pressure controls with which this machine is equipped do not accommodate basis weight fluctuations of large magnitude. Never before in this mill, however, has such a graphic record been available to demonstrate

the magnitude of the basis weight effect upon moisture content.

Having agreed that basis weight fluctuation is a bad thing, we ask ourselves what the charts can do to remedy the situation. The answer is: perhaps not much in themselves, but they do give certain clues. In this run it will be noted that the wildest basis weight fluctuation occurred at or near the beginning, and this is often the case. A systematic study of the stock consistency as supplied from the beater room during the first eight hours of each run might reveal that undue haste in filling the chests was tending to bring about a departure from standard procedure in filling and dropping beaters. Here again, the primary function of charts on finished production is to indicate *when* trouble is occurring. To eliminate the trouble additional charts often must be used to control some earlier step in the manufacturing process.

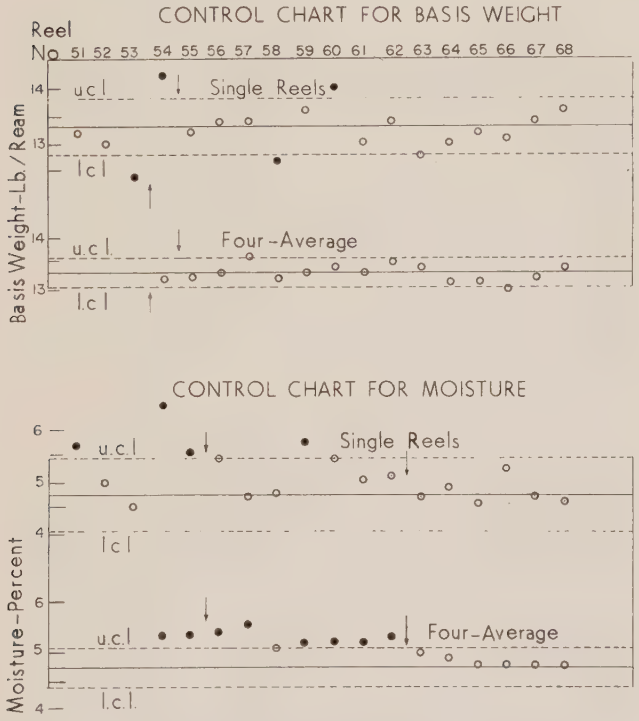

Fig. 2. A third run showing backtender's reluctance to be guided by quantitative moisture data

After the first four reels of this run, the individual reel charts for basis weight show good control with only two minor exceptions, and the four-average chart shows perfect control for the entire run. At this point it must be made clear that perfect control in the statistical sense and perfect control from the use requirement standpoint are not necessarily the same. It has been stated that the last fourteen reels of this run show "perfect" basis weight control statistically. However, in case this degree of control is not adequate for the customer's needs, it must not be decided that the situation is hopeless. Many of the causes of basis weight variation are systematic, that is, repetitive in their action. The statistical control limits shown on these charts were calculated from data obtained in production on this same machine in previous runs during which these systematic causes of basis weight variation were all at work. They include fluctuation in machine speed, stock pump surges, fan pump surges, consistency regulator hunting, and probably many others. Just because these causes are systematic it need not be concluded that it would be impractical to detect and eliminate them even though the point would be reached eventually where increasing sums of money might be required for the sake of only minor improvements in uniformity.

Unlike the first run described no *operating* difficulty during the third run hindered the establishment of the moisture content at any desired level. It is clearly evident, however, that the backtenders were unwilling to trust the information provided to them by the four-average chart. After noting the high moisture content of reels 54 and 55 on the single-reel chart, it is true, one backtender did make a downward adjustment, but this was insufficient to keep the points on the four-average chart within control. Furthermore, the high general average of moisture permitted the individual reel moisture for reel 59 to exceed its upper limit. After reel 62, however, the evidence provided by the four-average chart was so overwhelming that a further downward adjustment was made. Fortunately, the run continued long enough to demonstrate that the adjustment had been a proper one, the last six reels showed perfect statistical control.

This run is a startling example of the general truth that papermakers prefer to follow their own subjective impressions rather than quantitative data in regulating moisture content. The prevailing attitude is: (1) if there is calender blackening, the paper is too damp; (2) if there is excessive static, the paper is too dry; (3) if neither (1) nor (2) is the case, and if a suitable wisp of steam is rising from the drier felt at the dry end, the paper is just right. Now it must be admitted that all these qualitative observations are very helpful indeed during the first few hours of a run. The procedure used for moisture determination at this mill involves oven-drying for at least $1^1/_2$ hours; the backtender can hardly wait this long to make his initial adjustments. Furthermore, it must be remembered that the first representative moisture sample is usually not obtained until the end of the first reel, roughly ninety minutes after the start of the run. This means that the backtender has no quantitative information to go by until three hours have elapsed. There can be small wonder then that papermakers have learned to rely upon their own judgment and intuition in regulating moisture. The advantages of the control charts cannot be crammed down their throats.

In passing, it can hardly escape notice that the single-reel charts lack the sensitivity required for precise control. In Fig. 2 all but one of the moisture values beginning with reel 56 were within the statistical limits for single reels. The four-average chart, on the other hand, shows that the general average of moisture remained high until the correction following reel 62. If the backtender had heeded the message of the four-average chart, the process could have been brought into control at least six hours sooner and at least three reels more of standard quality paper would have been produced. In this case, it so happens that the correction should have been made after reel 59, and the

single-reel chart itself provided sufficient evidence to justify the correction. The main advantage of the four-average chart here would have been in indicating the required *magnitude* of the correction—in this case about 0.5% of moisture, or the difference between the four-average point for reel 59 and the solid horizontal line representing the desired moisture content.

A further advantage of the four-average chart is its clearer portrayal of the long-term trends during the run. In the absence of any basis weight or moisture corrections these are a valuable source of information on how careful the beater room personnel are in dropping beaters at a uniform consistency and even in their attention to such matters as the beating cycle which would affect the drying characteristics of the sheet.

STEPS IN THE DEVELOPMENT OF THE PROGRAM

One particular grade was selected in which the moisture content played a very important role as far as the over-all use behavior of the sheet was concerned. The moisture content of previous runs was analyzed, the control limits were established according to standard formulas, and for the first time the charts were posted at the dry end of the paper machines. No attempt was made to sell the charts to the operating personnel, but their questions were answered as carefully and completely as possible. The item charted was the average of several moisture determinations performed on specimens taken *across* the width of the sheet as each reel turned up. The moisture data were not further subgrouped for plotting, and the range was not determined as the run progressed. In spite of this simplified procedure it was found that the testing station personnel at first made some errors in plotting, sometimes failed to chart the data promptly, and in general considered the charts as quite a nuisance. Gradually, however, their accuracy improved, and they adapted themselves to the need for doing the work promptly and well.

The uniformity of moisture content during this period did not improve noticeably, and there was frequent evidence that the process was out of control in the statistical sense. Most striking was the tendency for the moisture content to persist for several consecutive reels within the control limits but on the same side of the average line. It was realized that this was an additional symptom of lack of control, but it was not considered expedient to use this criterion as the basis for corrective action. It was realized, of course, that, by subgrouping the data more sensitive limits could be employed, but the length of time which would be required to accumulate enough data for one point on the chart made this refinement seem unattractive. Reference has already been made, in the introduction of this article, to the difficulty of obtaining a representative sample of paper in the middle of a reel. Furthermore, it had always appeared to the writers that the practice of averaging the real data in subgroups of four or more tended to make the machine performance seem more uniform than it really was. It is a hollow satisfaction to see the sub-group averages "in control" when the single-reel data show a variation which is outside customer specifications or commonly accepted tolerances.

SUCCESSIVE DIFFERENCES AND THE "RUNNING AVERAGE"

Very early in the program, Geoffrey Beall, then on the staff of the Institute of Paper Chemistry, had been invited to visit the mill, check the validity of the charting procedures which were being employed, and acquaint all personnel concerned with the essential nature and the possibilities of the program. After the initial experience described above, it was considered expedient to seek more professional advice, so Dr. Beall was called in again. He suggested certain changes in the procedures used both for the original analysis of past data and for the continuous charting. The final methods adopted, which were the basis for the charts shown in Figs. 1 and 2, will now be described in some detail. Limits had hitherto been calculated according to the Range method described by Grant (*2*) using sub-groups of four. Although this method had its advantages, it did require the accumulation of about 100 reel samples before limits could be set up with some degree of confidence. Dr. Beall introduced the technique of successive differences which is really a modified use of sub-groups of two, the only departure being that each value is used twice. For example, in a series of reels numbered 1, 2, 3, 4, 5, etc., the difference in basis weight between reel 1 and reel 2 is the first range item; the difference between reel 2 and reel 3 is the second range item, and so forth. This technique has the advantage of affording the maximum use of all available data; it also seems to characterize better the *normal* variation of the machine which, it is assumed, can be reduced only by equipment modification. The average of a series of range items so determined is multiplied by an appropriate statistical factor to obtain the standard deviation of individual reels from the average of all basis weight items used. This standard deviation figure, in turn, is the basis for establishing the upper and lower control limits on the chart for single reels.

In the preliminary charting which was done at this mill the classical three-sigma limits were used—that is, the distance from the average or desired value to either control limit was equal to three times the standard deviation. In most cases, however, it was found that the values for single reels rarely fell outside these limits with the result that an unwarranted feeling of satisfaction with the product uniformity was developed. Furthermore, the three-sigma limits usually permitted more variation than was consistent with customer specifications, and it did not appear feasible to embark upon a wholesale program of customer re-education. For these reasons the two-sigma limits were substituted very early in the program. As every statistician knows, 95% of all the points should fall within two-sigma limits if the process is in control.

It has been mentioned earlier in this article that the single-reel charts were not found altogether satisfactory. It frequently happened that several consecutive points would occur on the same side of the average line but all within the control limits. In order to establish in a foolproof fashion whether or not this indicated lack of control, Dr. Beall introduced a supplementary procedure, which he called the "running average." In a series of reels numbered 1, 2, 3, 4, 5, etc., reels 1, 2, 3, and 4 comprised the first sub-group; reels 2, 3, 4, and

5, the second; reels 3, 4, 5, and 6, the third; reels 4, 5, 6, and 7, the fourth; and so on. The reels comprising each sub-group were averaged, and the resulting average value was graphed on the running-average chart. Since in all this work the standard number of items per sub-group was four, the term "running-average" was soon abbreviated to "four-average."

According to a law of statistics, the standard deviation for sub-groups of four is exactly half the standard deviation of the individual items. This explains why the control limits on the four-average charts in Figs. 1 and 2 are only half as far from the center line as are the corresponding limits on the single-reel charts.

The practical advantages of the four-average charts have already been stressed in the discussion of Figs. 1 and 2. It will suffice to summarize them here merely by stating that if the time should ever arrive when one chart or the other would have to be sacrificed in the interest of conserving space, the writers would favor the elimination of the single-reel chart rather than the four-average chart. It is felt, however, that *both* charts are essential to the successful application of any paper quality control program.

In other respects, it is believed that the charts are almost self-explanatory. The abbreviations u.c.l. and l.c.l. of course refer to the upper and lower control limits, respectively, indicated by the horizontal dotted lines. The four charts representing each run are synchronized with each other which permits inspection at a glance to detect inter-relationships. Points which fall outside the control limits appear as solid black circles for emphasis in contrast with the points within the limits which are left as open circles.

In both figures it will be noted that the first point on the four-average chart appears under the fourth reel of the run. The reason for this is obvious since each point on the chart represents the average of that point and the three preceding. Furthermore, whenever the machine is shut down completely during a run, the four-average charts will be vacant of points for three successive reels. For charting purposes it is considered that the complications of starting a paper machine even after a very brief shut-down are equivalent to those of starting an altogether new run. It is important to remember that a four-average point is to be interpreted as an average condition which obtained during the manufacture of the four reels just completed *and which still prevails at the moment.* If it is known that some pertinent operating condition has changed during the period in question, the average of the four reels can no longer be presumed to represent the conditions which prevail at the end of the period, therefore, no useful purpose is served by striking such an average.

A rigorous application of this reasoning would also require that the four-average chart be interrupted whenever an adjustment is made in basis weight or moisture. To date, however, this has not been done, mostly for practical reasons. In the first place, the paper tester is not always informed when such an adjustment has been made and so has no basis for interrupting the chart. Second, the adjustments in some runs are so frequent that almost all the four-average points would have to be eliminated. Accordingly, the four-average charts have been interrupted only in the event of an actual wire shut-down, and where necessary mental allowances have been made if the next point or two after an adjustment remain outside the control limits. A similar compromise has been made in the case of all breaks, whether at the wet end or dry end of the machine, i.e., the four-average charts have not been interrupted.

PERSONNEL FACTORS AND THE HUMAN ELEMENT

It has been mentioned that a sincere attempt was made at the beginning to acquaint all personnel with the essential nature of the control charts and with their potential contribution to quality control. This program of orientation included key personnel at all levels, from top management to operators and paper testers.

In spite of these efforts and in spite of the obvious advantages of the control charts as an additional tool, the machine tenders and backtenders have been rather slow to use them to the fullest possible extent. An illustration of this failure is given in Fig. 2 where the four-average chart showed the moisture content to be out of control for several reels before the necessary correction was finally made. When such a thing happens, there is always a temptation to issue direct orders—"Get this process in control or else!" Such action has never been taken in this program, however, and it is hoped that it never will be. It is felt that a program of this nature can succeed only through cooperation, not by coercion.

As an illustration of what may be accomplished by *indirect* action, however, one homely experience may be cited. As in most mills, the previous testing program had involved the posting of numerical results from each reel sample in the machine room for the guidance of the machine tender and the backtender. The tabulated data included both the average basis weight for the reel and the results of individual weighings at six places across the width of the sheet. This practice was continued for a while even after the inauguration of the charting program. It was soon found, however, that from force of habit the machine tender always looked at the numerical data first and often failed to glance at the control chart. To correct this difficulty the paper testers were instructed to omit the average basis weight figure from their numerical results entirely in the hope that the machine tender would thereby be forced to look at the control chart. It is believed that this expedient has been at least partially successful.

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Drying of Low Density Fiberboards in Roller Driers

ARTHUR S. HOLDEN, JR.

Fiberboard can be manufactured using machines that are similar to many used in papermaking except the drier which, conventionally, is a roller type. Many construction details have been learned during the past twenty years; however, zoning, application of heat and air must be worked out to fit each product, and extensive laboratory testing is the only practical means of acquiring necessary data. The fiberboard industry has enjoyed constant growth since World War I and it is anticipated that a natural expansion will continue. Some new specialty boards which may be developed will very likely require roller driers as part of their manufacturing process.

THIS PAPER might be considered an advance into either the "infrared" or the "ultraviolet" end of the papermaker's spectrum in that paper or paperboard usually does not exceed $^1/_{10}$ inch thick, whereas fiberboard is more frequently manufactured with a nominal finished thickness of $^1/_2$ inch.

There are a considerable number of phases in common in the manufacture of paper and fiberboard, starting with the raw material which in most instances is wood and carrying through many of the machines for fiber preparation and formation, a number of which have been developed by companies primarily serving the paper field.

FIBERBOARD MANUFACTURING PROCESS

For the benefit of those who are not familiar with the process of fiberboard manufacture, a brief review might be helpful. The principal steps in manufacturing fiberboard include the following: (1) refining, (2) forming, (3) pressing, (4) wet cutting and trimming, (5) drying, (6) dry trimming, (7) packaging, and/or (8) further remanufacture.

The stock most commonly used as mentioned above is wood which may be either hard (deciduous) or soft (coniferus); however, the latter is predominately used although in those localities where hardwoods can be obtained at a sufficiently low cost, certain percentages of hardwoods may be blended with the softwood stock. Other materials which have been successfully used for fiberboard stock, include the following: corn stalks, bagasse, licorice root, pine stumps, and to a lesser degree, other more diverse products containing fibers of sufficient strength and length to provide a good mat.

Refining

Refining of the raw material is usually accomplished by one of the following methods: (1) single or twin disk refiners, (2) stones, or (3) combination of (1) and (2). Most papermakers are familiar with disk refiners such as the one shown in Fig. 1 which is manufactured by the Bauer Brothers Company. Stock in the form of chips is fed into the eye of a rotating disk and by centrifugal action is thrown outward. The serrated faces of the disks accomplish a rubbing action breaking down the chips into fiber bundles. The chips may or may not have been previously cooked. Usually no chemical is required although in some instances a mild alkali cook can be used to advantage. A pressure of 150 pounds and a period of 45 minutes are considered adequate for the most extreme conditions.

In some mills the Asplund defibrator, a product of the American Defibrator Company, is used to provide a portion of the stock in order that the furnish contain an increased percentage of slower stock. The Asplund may or may not be equipped with a steam reaction chamber ahead of the disks.

When stones are used the machines are of the conventional groundwood type such as manufactured by Montague Machine Works. Usually these are equipped with hydraulic feeds and preferably have two pockets so that loading of one can be accomplished while the other is feeding. The stones have a pattern designed to be most efficient for the particular type of wood being handled and are, of course, driven by large, direct-connected motors. In some mills groundwood screenings are diverted to disk refiners and the fiberboard is, therefore, a byproduct of the papermaking operation. In other mills where stones are used, the screenings from the stones are fed to disk refiners and their products subsequently blended with the groundwood stock.

Fig. 1. Bauer disk refiners in operation

Board Formation

Formation of fiberboard was first accomplished by means of a screen and suction box. The Homasote Company of Trenton, N. J., The Union Fibre Company

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at Winona, Minn., and The Minnesota and Ontario Paper Company, International Falls, Minn., were among the pioneering firms who developed processes for manufacturing fiberboard prior to World War I. Several plants today still use the screen and suction box method of formation; however, approximately 95% of today's production is made on continuous machines of one type and another. Large diameter cylinders covered by screen with the headbox a sufficient distance above them to provide a hydrostatic head constituted the arrangement used in early efforts at continuous formation. The Oliver United Filter Company has developed cylindrical board formers and these machines are found in many fiberboard plants today. As may be seen in Fig. 2 showing a small narrow face machine, the cylinder is suspended in a tank wherein the stock is circulated and suction

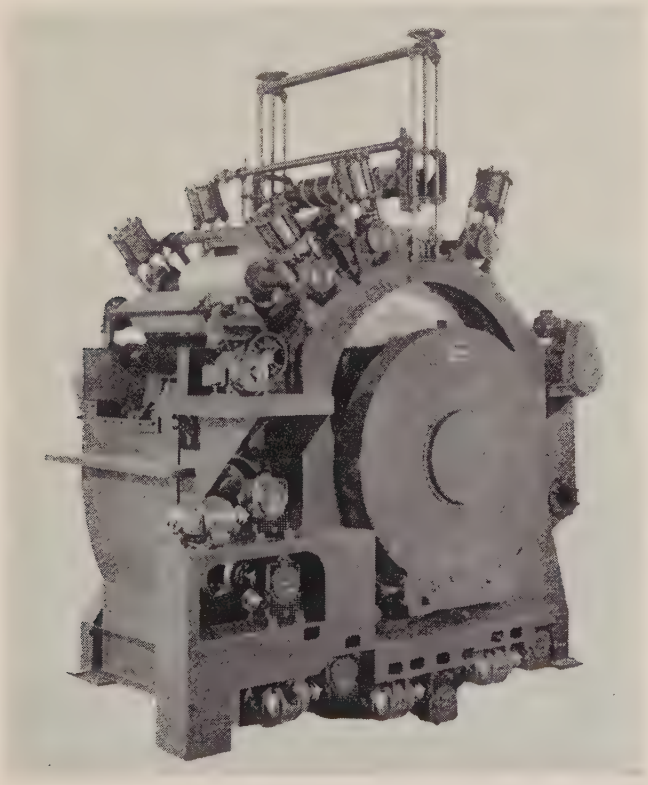

Fig. 2. Small narrow face cylinder-type board forming machine

applied to bottom segments of the drum while submerged in this tank where a consistency of approximately $^1/_2$% and freeness of approximately 40 seconds prevails. As the cylinder rotates and the mat reaches a point at the top, suction is replaced by pressure and the mat lifted from the cylinder.

With the advent of higher machine speeds considerable thought has been given to the desirability of a fourdrinier-type forming machine such as is commonly used in the paper industry. At least three such machines have been built by The Downington Manufacturing Company, and are in successful operation today. The belt sections are relatively short, usually not more than 20 feet in length; however, suction rolls and Rollafiners are usually installed to promote rapid separation of water from the stock. One such machine of this type is shown in Fig. 3.

Pressing

Pressing is accomplished by pairs of rolls as may be seen in the machine illustrated in Fig. 4. Wires rather than felts are usually used and it is possible with a fourdrinier-type forming machine for its wire to run through the press section. In some instances the top press rolls are cantilever mounted so that a continuous wire can be used. When this practice is not followed the wire must be sewn or brazed together. The pressing problem in connection with a low density fiberboard

Fig. 3. Fourdrinier-type board forming machine

is to extract as much water as possible without concentrating the mat to a point where dry weight exceeds 700 or 750 pounds per thousand feet, $^1/_2$ inch thick. This corresponds to a density of 16.5 pounds. Low density is essential for the principal uses of fiberboard which take advantage of its insulating and acoustical properties. The moisture content leaving the presses has been reduced in modern installations to 60 to 62%. In some special cases even lower moisture contents are possible; for example when a hardboard mat is prepared this may even reach a figure of 50%.

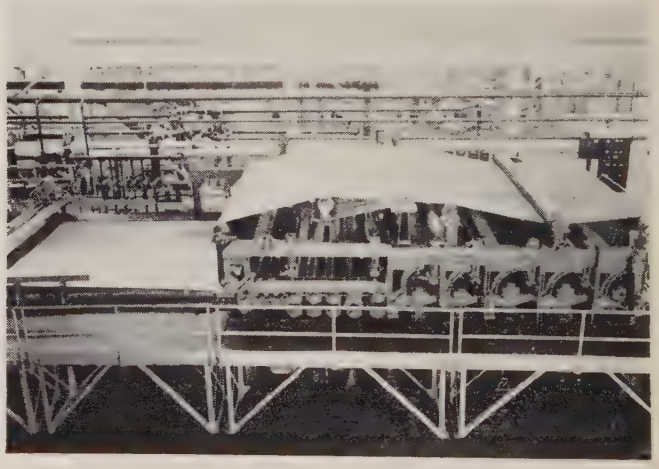

Fig. 4. Downingtown press section

Up to this point the mat is continuous; however, for drying it is desirable to cut it into sheets 8 or 12 feet wide (plus trim) by 8 to 24 feet long (plus trim). These individual sheets may be conveniently fed into a multiple deck drier and free shrinkage is possible without developing strains or cracks. If the mat were not cut into sheets a one deck drier would be required that would be 5000 feet or more in length to handle the production of a typical large plant. Such an arrangement would result in tremendously high initial building

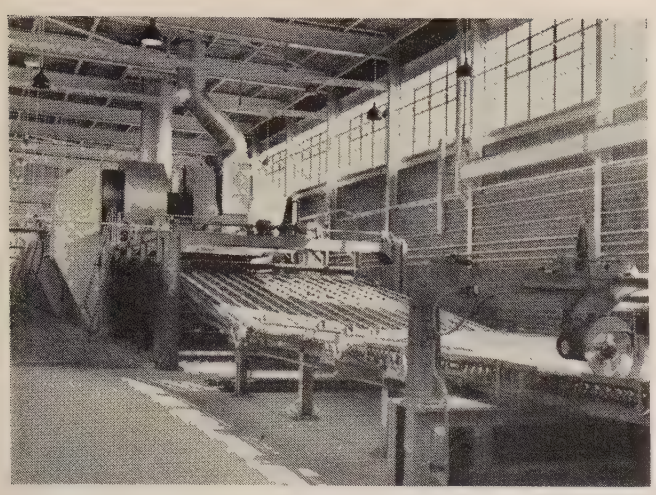

Fig. 5. Wet saw and automatic drier feeding equipment

and machine costs not to mention operating problems and added fuel costs. One manufacturer does dry the continuous mat prior to trimming; however, this practice is not common and does require considerable manufacturing technique to accomplish successfully. Widthways trimming after pressing is accomplished either by adjustable side trim saws or adjustable, high-pressure water jets. Cross cutting of the mat is done by means of a saw mounted in a carriage which travels diagonally with forward movement equalling progress of the mat so that when the saw has completed its traverse, a perpendicular cut has been made. The entire carriage lifts clear of the sheet and returns to its starting position ready for the next cut. This machine may be seen in Fig. 5.

Automatic Feeding

Automatic feeding of the boards into a multiple deck drier is an interesting operation to watch because manual effort has been completely eliminated. An electric control panel serves as the nerve center and by the means of electric switches and clutches, each sheet is accelerated to provide a time gap and directed to the proper deck in the drier and then reduced to drier speed. One man is usually assigned to watch all the equipment and can step in and take over the control at any time.

At higher speed operations, i.e., above 30 f.p.m. forming speed, the wet saw table which is usually made up of 3-inch diameter rolls set on 4-inch horizontal centers, must be divided into sections which must successively operate at high speed (three to eight times forming speed) and forming speed. Light contact electric switches are located at appropriate points so that the tail end of the board passing from under any given switch operates an electric clutch causing the table section immediately behind to return to forming speed, so that it will be correct for the leading edge of the oncoming mat. With this system the soft wet board is always in contact with rolls turning at the proper speed and no dragging, scuffing, or sliding of the under side of the board results, which would otherwise cause blemishes. Coating of the boards when wet is a practice being followed by a number of manufacturers today, and the coating is usually applied on, or just ahead of, the wet saw table. The subject of board coatings is one which might very well be considered as an independent paper and is merely mentioned here in passing. The advantage of applying the coating when the mat is wet is that after water has been removed from the board, the coating may be set without special handling through an auxiliary small drier.

The rolls in the feed section of the drier are usually driven by small pitch roller chain in order that a surface speed of some 200 f.p.m. may be obtained. Each deck operates at high speed when the tipple moves into position for a given deck through the medium of an electric clutch in the high-speed drive unit which overruns the drier drive. Adjustable electric switches regulate when the deck returns to drier speed and these are activated by the leading edge of the board being fed.

The forming machine, press section, wet saw, wet saw table, tipple, and the high-speed drive unit in the feed section must all be driven at a synchronized speed. This condition is identical to that found in a paper machine and the same problems of maintaining zero tension prevail. Early installations employed the use of a line shaft with cone pulley drives; however, many of the newer plants have taken advantage of the so-called "electric line shaft," involving independent direct current motors operated through a common control and each having an individual rheostat or vernier adjustment to compensate for lengthening of the board under the press section and similar variations which require compensation.

Driers

Roller driers are universally used for the drying of fiberboard. These serve to convey sheets through succeeding zones wherein appropriate temperatures and air velocities are maintained in order to accomplish the most rapid and satisfactory drying possible. Since the wet mat has a thickness of from $^3/_8$ to 1 inch it would not be possible to carry it around the periphery of large steam-heated drums as is the common practice in the manufacture of paper since due to the thickness, the board would rupture and further, since there is a very large amount of moisture to be removed per square foot, it is desirable to have both top and bottom surfaces exposed to allow the free escape of moisture, especially in the early periods of drying.

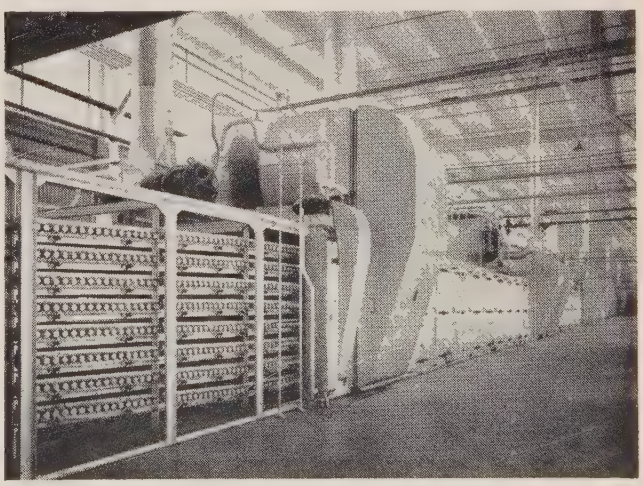

Fig. 6. Typical 8-deck fiberboard drier

Modern roller driers, such as shown in Fig. 6, are related to the veneer driers developed in the early 1900's. These machines similarly employed rolls of various diameters and lengths as conveying medium for sheets of veneer. The rolls were usually in pairs with the top rolls serving to flatten and iron the sheets minimizing warpage. A fiberboard drier today is made up of either 6, 8, or 10 decks of single rolls usually 3 inches in diameter and having lengths slightly in excess of the nominal board width which is either 8 or 12 feet.

Drier Construction

The body of the drier is made up of a structural steel frame adequately braced to maintain alignment when heated. This framework is usually built in sections with appropriate expansion joints between sections. Each section is anchored at one point and the remaining portions mounted on roller bearing plates which allow longitudinal movement when expansion and contraction occurs without crosswise movement which would result in misalignment likely to divert the sheets from their proper path. So-called "cages," which are horizontal members, serve as supports for the bearings. The bearings may be either ball or graphite. A special ball bearing has been developed for this service which will stand up satisfactorily under temperatures as high as 400°F. Because of the thousands of bearings in any one drier, it would be a difficult problem to set up a satisfactory lubrication program and, in addition, the presence of oil would serve to accumulate fine dust and other particles which would be detrimental to the free operation of the balls. Therefore, the common practice today is to use a bearing which is self-cleaning and which will operate successfully without lubrication even at elevated temperatures. Above 400°F. a special graphite bearing is preferred and there are several commercial graphite compounds today which have sufficient mechanical strength to serve well. Earlier efforts in this direction were along the lines of brass bushings having pockets which were filled with graphite. These, however, have been superseded by the newer products just mentioned.

Each roll must be driven and the sprockets preferably have a long pitch. The chain drives from the top side and suitable hold-downs and chain returns must be provided to keep each chain properly moving in its individual path. A large compound gear train frequently termed a "drive rig" serves to pull all the chains in all of the decks. Some type of variable speed is necessary to allow variation for different moisture contents and different thicknesses of board. Proper chain tension is now obtained on most of the new driers by means of a counterweighted automatic chain tightener. Former devices were of the screw type and required manual adjustment.

Early efforts at drier construction followed along the lines of placing the rolls on close vertical centers in order to make the machine as compact as possible. Experience has shown that this is wrong and today great emphasis is placed on liberal spacing between decks for free access and heavy construction to withstand high temperatures. Similarly, the insulated panels which were first used for the drier housing have now been supplemented by hinged doors with large rotary cam locks which can be conveniently opened for servicing, cleaning, and also if the board ignites. Even the large supply and exhaust manifolds which convey the air into the sides of the drier are now being hinged.

A drier foundation today is principally a slab of concrete, reinforced to carry the necessary load. It is no longer common practice to provide tunnels in the foundation for recirculating the air. In fact, separate heaters when located alongside the drier now connect to the drier with overhead ducts, or in some instances, the heaters are placed on the second floor of the building above the drier proper and interconnected with insulated ducts. Fin-type steam reheaters and gas heaters have been developed of sufficiently light construction so that they can be mounted on the top of the drier which minimizes the length of recirculating duct and reduces friction losses.

Unloading

Automatic unloaders have now superseded manual unloading in virtually all plants. These machines discharge individual decks of the drier onto a common single level from which the boards feed into the dry trim saws. These saws are made up of two arbors located at right angles to each other in which the individual saw blades are mounted. The board moves through one gang and crosswise through the second. The board may be either trimmed along the edges and reduced to standard sizes such as 4 by 8, 5 by 10, etc., or may be cut down into small pieces suitable for insulated siding or acoustical tile. Numerous remanufacturing operations are required for specialty products. Large sheets are merely packaged and arranged for shipment.

HEATING MEDIUMS

Driers are generally classed, in addition to size, by the type of heat used. These include the following: (1) steam, (2) gas, and (3) indirect.

Steam is by far the most commonly used for a heating medium and has a distinct advantage in that control is easier. Coils above and below each deck of rolls provide radiating surface that is directly effective on the surfaces of the board. In addition, a fin-type reheater located in the air circulating system can be used to step up temperatures to provide a differential 20 to 30° between the wet and dry end in a given zone. In recent installations the pipe and fittings within the drier have been of heavy duty welded construction which makes possible use of steam at pressure up to 400 p.s.i.

With 250 p.s.i. the temperatures maintained compare favorably with direct firing and it is expected that at 400 p.s.i. this rate may even be exceeded.

In certain localities where gas is available at an attractive rate, it provides the most logical fuel to use. Recent gas heater designs eliminate the necessity of heavy refractories and, as a result, may be mounted on the top of the drier so that the recirculated air passes directly through the heater. With this arrangement, the air picks up the heat and delivers it into the

interior of the drier dropping in temperature as it passes through a given zone. This temperature drop should be kept in the neighborhood of the 150 to 200°F. Care, of course, should be exercised to obtain prompt control of the heater so that scorching of the board at the hot end of the zone will not occur, especially when gaps resulting from breaks or interruptions in forming are passing through the drier.

To the author's knowledge, oil is not now being used to heat directly a fiberboard drier and presumably this is because of the hazard of smudge and soot, plus a problem of neutralizing the sulphur usually found in substantial quantities, especially in heavier oils. Some machines were built for direct oil firing some years ago but now have either been converted to another type of heating or the heaters were designed for combination firing and are being operated on the indirect basis. In such cases, the air accomplishing drying is recirculated through tubes in the heater and into the drier, and the heater is located adjacent to the drier with suitable interconnecting ducts between. Most engineering studies which have been made seem to indicate that if oil is used, it should be used under the boiler which then serves as a heat reservoir which may be drawn on as required and as needed by the drier. The initial cost of an indirect heater is proportionately high and since most fiberboard driers today have a length of from 200 to 600 feet, a number of heaters with their refractory brick settings would be required to supply heat at points where needed. The maintenance and supervision associated with a number of such units woud, of course, be considerably more difficult than with a single steam boiler.

DRIER PERFORMANCE

Although no absolute information is available as to exactly how water leaves a thick fiber mass the following steps are generally conceded to occur in a roller drier:

1. Board and water are brought up in temperature until the water reaches a point slightly below 212°F., probably 190 to 200°F.
2. Water near the surfaces of the mat reach 212°F. and moisture starts to leave board.
3. Temperature throughout board increases and as temperature at any given depth from surface approaches 212°F. vapor pressure becomes sufficient to force moisture outward.
4. Velocity of air and superheated steam over surface of board carry vapor away by convection. A good sweeping action is essential to maintaining a rapid rate of water removal.
5. Capillary attraction of dried surfaces assists in drawing moisture from the wet core. This takes place through the interstices between fibers and through cells themselves.
6. After the board has been removed from the drier capillary action continues at a decreasing rate over a long period of time. At first equilibrium of moisture content throughout a given board or stack of boards begins to prevail. Then if the boards are below 5% moisture from the surrounding air is deposited. Since

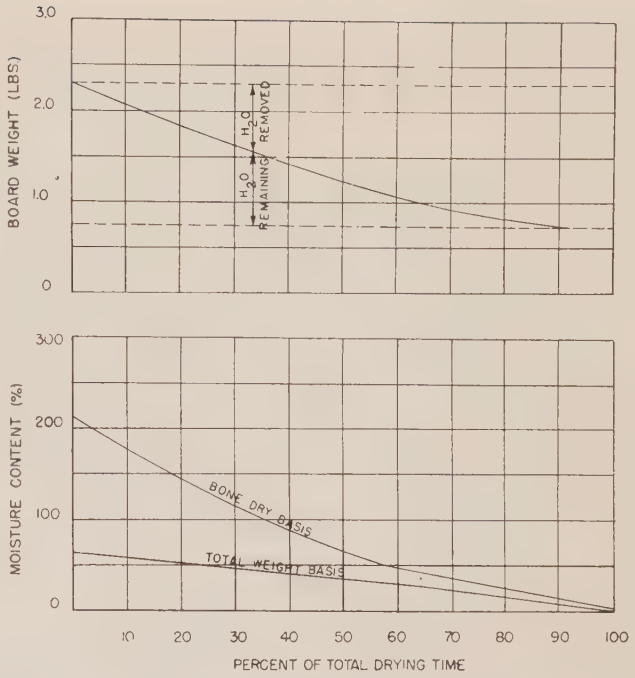

Fig. 7. Typical moisture removal curves for ½-inch fiberboard

size is added to the fiberboard further moisture pickup from the air is extremely slow.

It is of special interest to note that the moisture released from the board promptly converts from vapor to superheated steam due to the fact that the temperatures in the drier are well above 300° and pressures do not exceed 1 inch. It is interesting to note that the superheated steam which is in the form of a gas has an even greater affinity for absorbing moisture by convection than air. Because of this phenomenon the amount of venting through the exhaust stacks is less than commonly supposed since only the volume of superheated steam formed from the water evaporated need be vented, and no fresh air is required to promote drying.

A typical water removal curve in a fiberboard drier

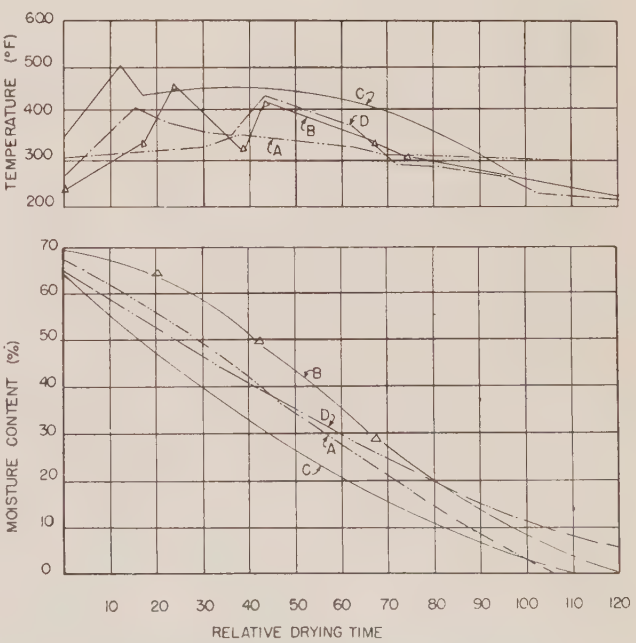

Fig. 8. Comparative drying times for ½-inch low density fiberboard in typical Coe roller driers

is shown in Fig. 7. Other properties including change in both wet and dry moisture content may also be noted. Proper zoning of the drier is necessary to obtain temperatures as needed to make possible a maximum water removal rate.

In Fig. 8, a comparison is made between several different driers, and the effect of the temperature variation on water removal rate can very clearly be seen. In tests A and B initial temperatures are not maintained as high as is desired and, as a result, the rate of moisture removal is not as rapid as in the case of C and D, especially the former. Considerable study must be made with any new product in order to properly design a drier to obtain the maximum speed and still not produce a harmful effect on the board. Careful zoning and the use of adequate but not excessive air circulation so that velocity of air over the surface of the board is correct, in addition to certain mechanical design features are requisites for the construction of a good fiberboard drier.

Perhaps it would be well to review some of the pertinent considerations that are necessary to study when the problem of drying a new product is presented. These include the following: (1) physical characteristics, (2) temperature limits, (3) rate of water removal, (4) maximum practical air velocity, and (5) other special considerations.

A roller drier finds its more common application in products which are of a relatively light weight and have sufficient mechanical strength even when wet to pass from one roll to another on 3 or 4 inch horizontal centers. Heavier products could not successfully be carried on rolls as small as 2 or 3 inches in diameter and horizontal roll spacings of as much as 6 inches provide too large a gap for most products when wet. In some instances a combination of conveyor and roller driers can be used to advantage. The belt conveyor drier, of course, provides 100% support and, therefore, the thinnest of materials can be handled in this manner. Paper machine felts are in reality a conveyor which serves this purpose. The conveyor drier, however, requires considerable volume per square foot of holding capacity and, therefore, its use should be restricted only to that portion of a drying cycle where physical strength absolutely requires its use.

Relatively high temperatures can usually be applied to most produucts in the wet state. There are certain types, especially paperboards, however, which tend to blister, crack, or scorch. In the latter stages of drying, temperature must be applied with great care and proper control instruments used. In fact, with low density fiberboard the sheet can ignite and spray systems are frequently installed in the last half of the drier to facilitate quenching of fires when they occur.

Laboratory studies must be made to determine the rate of water removal for different temperatures and different combinations of temperature and air velocities. After a study of this kind has been made, the necessary facts will be at hand for undertaking the design of a roller drier. It has been found that laboratory tests in order to be successful cannot be limited to so-called "hand-samples" approximately 1 square foot in area but rather ample material must be available, running into the hundreds or thousands of square feet, depending upon the complexity of the problem. Suitable laboratory driers are available in this country being located at The Fibre Products Laboratory, Springfield, Ohio, Forest Products Laboratory in Madison, Wis., Johns-Manville Research Center, Manville, N. J., and The Coe Manufacturing Company, Painesville, Ohio. In the first laboratory mentioned above, complete facilities are available for refining the raw material, forming, pressing, and drying it into sheets.

Although the conventional manufacture of paper and paperboard does not lend itself to roller drying, there are many speciality products such as transformer board, mill board, etc., where controlled drying is necessary and the zoned roller drier provides an excellent means for accomplishing this result. There are numerous new products under consideration today, some involving synthetic resins which undoubtedly will be most successfully dried on the roller-type machine.

PREDICTED APPLICATIONS

It might be of some interest to mention some modifications in standard, low density insulation board manufacture which are either being followed today or under contemplation. High density hardboard which has found wide application and acceptance for many years has traditionally been made by the introduction of a wet mat into a multiple opening hot plate press where both drying and compression were obtained. A number of installations today are based on predrying the mat with identical equipment and in a manner similar to that used for the manufacture of low density board, the dried mat then being introduced into a multiple opening press and densified. The press cycle under these conditions is approximately one tenth of that required when wet mat is handled, and the finished product has strength and other characteristics that are comparable. There are other advantages, too, including having both sides smooth, available for use, and the fact that a plant so set up can interchangeably produce either hard- or softboard as desired.

One horizon which is being explored by a company recently formed and which should be in commercial production within another year employs the use of a lightweight lava aggregate known as pearlite which is prevalent in the Rocky and Sierra Nevada Mountains. This rock formation is first treated in furnaces and exfoliated. As it is extremely light weight it has a multitude of microscopic air cells which provide excellent insulating qualities. When combined with news to provide strength, the resultant product has much the same properties as conventional low density fiberboard, in addition to being somewhat lighter and also more fireproof.

Successful fiberboards have been made from mineral rock fibers and glass fibers in combination with news. In some instances binders have been added. To date none of these products is yet available on the commercial market.

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The Surfaces of Cellulose

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THE SUBJECT of this paper "The Surfaces of Cellulose" was selected for two reasons. The first of these is because most applications of cellulose depend on its surface properties—either the external surfaces of fibers which govern their use in papermaking or the internal surfaces of cellulose which largely govern its chemical uses. The second reason is that a consideration of the internal surfaces of cellulose touches on so many of its chemical characteristics that it should open up a wide field for discussion.

EXTERNAL SURFACES

There is little or no difficulty in understanding what is meant by the external surface of cellulose. It is a microscopic surface and bounds the external dimensions of the solid cellulose particles whether these be fibers, fibrillae, or synthetic forms. It is particularly these surfaces of fibers or fibrillae which are of importance in papermaking.

Paper consists of a thin, compacted mass of cellulose fibers or fibrillae which are joined to one another by adhesive forces characteristic of cellulose and of very considerable strength. These adhesive bonds are set up wherever a cellulose surface, wet with water, dries in contact with another similar surface. Consequently, it becomes of interest to the papermaker to have some understanding of the mechanism of such bonding and also of the amount of surface available to form such bonds.

The phrase "fibers and fibrillae" has been used and it is well to be clear as to what is meant. The term "fibers" presents no difficulty. Normally it means the elongated cells of natural growth, whether these are cells of wood, cotton, flax, or other cellulosic natural material. If artificially made fibers are mentioned, they will be specially defined. By fibrillae will be meant the fiberlike portions of natural fibers into which these latter tend to fracture when they are mechanically stressed in the presence of water, whether this stress is due to swelling agents or by beating action. They may or may not be attached to their parent fibers. The question as to whether these fibrillae preexist in the natural fibers or whether they simply result from cleavage may be left aside for the present. Using the term fiber to include fibrillae will simplify discussion here.

If we, for the moment, also leave aside consideration of the mechanism of bonding of fiber to fiber, the important thing in the preparation of fibers for papermaking is the extent of the surface available for bonding. The important thing in the operation of papermaking is the degree to which this surface is utilized. An obvious need is a sound and convenient method of measuring the total surface available for bonding. Such surface would mean all external surface of solid cellulose particles. A need of only slightly less consequence is for some index of fiber shape. For papermaking purposes it is of importance that the cellulose be fibrous in form so that the particles may contact and bond with a very large number of other particles. A large ratio of length to diameter is essential.

Up to the present, only two or possibly three methods of measuring total surface of fine particles seem appropriate for this work. Microscopic observation of the external dimensions of fibers can be made only when these are of comparatively large size as in the case of naturally occurring fibers. Even in the best of circumstances, this method is tedious and of low accuracy; in the case of beaten cellulose, or its equivalent, mechanically ground wood pulp, it is practically impossible. In such stock there is a very large proportion—and one of high importance—where the fibers, of fibrillae, have diameters at or below the limits of microscopic observation.

Another method, of somewhat wider usefulness, is that of Clark (*4*). In this method a thin film of silver is deposited on the fiber surfaces and the area of this film is estimated from its ability to catalyze the decomposition of hydrogen peroxide. In this method it is assumed that the silver film is everywhere of equal catalytic effect so that its surface area is the only variable which alters the decomposition rate of the peroxide. While one can question the uniformity of such films it is conceivable that, by proper control of precipitation conditions, it may be made sufficiently uniform for the purpose. A much more serious objection is that, where the silver is deposited on very small particles—those with diameters of about 0.1 mu, for instance—a very moderate amount of handling may cause agglomeration so that only the surface of the agglomerate is measured. In our laboratory we attempted, by this method, to follow the increase of surface of pulp during the beating action. For the earlier stages of beating there was no difficulty. But with more extensive fibrillation the results became erratic and it was sometimes found that estimated surface area actually decreased although all other indications were to the contrary. Possibly this was due to faulty technique in applying the method.

The third method applicable to such measurement is that based on measuring the permeability to liquid flow through a mass of the pulp and calculation of the surface area by means of the Kozeny equation. In a crude and empirical way this method has been used by papermakers in all ages. In all papermaking operations the "wetness" of the stock, or its reluctance to part with its water when first formed into a sheet, has been considered an important criterion of the stock quality. In later years various methods for measuring freeness or drainage resistance have given numeri-

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cal value to this quality. But all such methods are still empirical and are related to actual surface area in a relative or qualitative way only. During the past two years, A. A. Robertson, working under the direction of S. G. Mason, has made much progress toward reducing this method to one of considerable precision so that it seems to measure surface areas with a fair degree of accuracy. This work is not yet ready for publication but a general description may be given here.

The Kozeny equation may be developed from the Poiseuille equation as follows. Normally the Poiseuille equation is written as applicable to a circular tube. To apply it to a tube of other shape we must replace r, the radius of the tube, by m, the hydraulic radius or area/perimeter of cross section. Also, a shape factor must be introduced appropriate to the shape of the section. Written with these alterations the Poiseuille equation is

$$\frac{Q}{A} = \frac{1}{f}\frac{Pm^2}{L\eta} \qquad (1)$$

where

Q = the volume rate of flow
A = the area of cross section
P = the pressure drop
L = the tube length
m = the hydraulic radius
η = the viscosity of the flowing liquid
f = a shape factor which depends on the shape of the tube cross section

In a porous mass of interconnecting passages and having a void fraction ϵ, the open area of a cross section of the mass will be ϵA, where A is now the area of the mass through which liquid is flowing. This value ϵA will replace A in Equation (1).

The solid fraction of the mass is $(1-\epsilon)$. If this has a specific surface (area of surface per unit volume) of S, then the total surface of the mass is $S(1-\epsilon)$ for unit volume of the bed of material.

The hydraulic radius (area/perimeter) of a tube is the same as the volume/surface of the passage. Hence, we can write $\epsilon/S(1-\epsilon)$ as the mean hydraulic radius of the passages through the mass. These passages do not proceed directly through the mass but by a zig-zag path and hence their length is greater than L, the thickness of the mass. Also, the pressure difference per unit length of passage will be less than P/L, the pressure drop per unit thickness of the mass. Factors to allow for these features of the mass structure are, in part, empirical and can conveniently be merged with the shape factor, f.

With these substitutions in the Poiseuille equation it becomes the Kozeny equation,

$$Q = \frac{1}{f}\frac{AP\epsilon^3}{L\eta S^2(1-\epsilon)^2} \qquad (2)$$

This equation has been found to be valid for the flow of various fluids through fibrous masses, within certain limits of void fraction ϵ. Thus Sullivan and Hertel (*16*) using air and textile fibers found it valid if ϵ was less than 0.88. Wiggins (*15*) found it valid for glass wool and for cellulose acetate fibers and various liquids for values of ϵ lying between 0.85 and 0.93 and also found that nonuniformity of the bed had little effect. Working with paper pulps, Stuart (*13*) found irregular results due to nonhomogeneous packing of the pads if ϵ was less than 0.93. Robertson has improved the technique of pad formation so as to almost eliminate this latter trouble and has been able, in consequence, to obtain good results with such pulps over a rather wide range of void fractions.

In order to use this equation and technique for measurement of effective surface area of papermaking pulps, it is necessary to know the effective solid volume of the pad through which flow takes place. As the total volume of the pad and the weight of pulp in it are readily determined, this amounts to finding the effective specific volume of the wet pulp. Such volume is obviously much greater than the specific volume of the cellulose material, because it must include all water which has been imbibed by the cellulose in any way so that it does not take part in the flow through the pad. At first, this specific volume was taken to be the volume of cellulose in water (0.62) plus the volume of water sorbed to saturation from vapor (0.30), giving an effective specific volume of 0.92. Experiments showed that this value was much too small to be correct. And consideration of the matter indicated that this should have been expected. Unbeaten pulps have a central lumen which adds appreciably to the effective volume. Also it is likely that pulp in liquid water, where surface tension is eliminated as a compression force, can take up more than 0.30 gram of water per gram of pulp. In beaten pulps there is also the likelihood of the effective volume being increased by the creation of loose aggregates of fibrillae which effectively immobilize much water which thus becomes part of the specific volume.

This difficulty about assigning a value to the specific volume was met experimentally by measuring the permeability of pads containing from 5 to 13% of pulp and so plotting the resultant data that it was possible to determine both the effective value of the specific volume and the specific surface. It was found that both of these were increased by beater action. A typical set of values of specific surface as freeness is decreased by beating is as follows.

Freeness (Canadian Standard), ml.	*Effective volume/gram, cc.*	*Surface/gram, sq. cm.*
682	3.13	12,960
515	4.03	21,450
403	4.30	29,430
275	4.60	39,500
175	4.60	49,400

It is expected that further work will show correlations between such values and other papermaking characteristics of pulps.

THE INTERNAL SURFACE OF CELLULOSE

The external surface of cellulose is something rather obvious and there is no doubt about its meaning and existence. This cannot be said of the internal surface. Its existence has been postulated chiefly to account for certain phenomena, particularly those of sorption. But some investigators find it possible to account for these phenomena on other grounds. Thus Hermanns (*8*) states "Since sorption is associated with a process of molecular dispersion (quite comparable to the solution of one substance in another) rather than with

surface adsorption of supra molecular particles, as was the idea of classical colloid chemistry, there is no more reason to speak of internal surface action than there is in the case of an ordinary mixture of two fluids, or of the solution of a solid in a fluid."

Hermanns makes a rather good case for considering solid cellulose as a mixture of two phases, one crystalline and one amorphous. The crystalline phase, he considers, is impervious to water, except possibly on its outer layer. The amorphous phase, according to his ideas, is the same in all varieties of cellulose and reacts with water to form cellulose hydrates and solid solutions of water in cellulose. Samples of cellulose differ from each other in the ratio of amorphous to crystalline and in the kind of crystal present.

He points out that the S-form of the vapor pressure–water content curve is of quite the same nature as that obtained when water is added to sulphuric acid where it is understood on other grounds that the water first forms hydrates of the acid and that these are dissolved in the remainder. As the water content increases, the solution gradually changes over to one where the water is the main constituent and so we speak of a solution of the acid in water. In a parallel manner, Hermanns looks on the first water sorbed by cellulose as forming hydrates and on the later stages, where the water approaches its maximum sorption, as a solution of cellulose in water.

In like manner he shows a parallel in the matter of specific volume. A small volume of water added to a concentrated sulphuric acid solution does not increase the total volume by direct addition—there is a certain disappearance of volume. Whether this is due solely to a packing effect whereby water molecules fit into spaces between the acid molecules or whether it is due to a compression brought about by the attraction between water and acid is a side issue. Perhaps, to some extent at least, these are only two ways of saying the same thing. In any case we have the corresponding condition when water is added to cellulose. If a gram of dry cellulose with a volume of 0.64 cc. as measured in helium is put into a volume of 10 cc. of water, the result is not 10.64 cc. total volume. It is 10.62 cc. There has been a disappearance of volume of 0.02 cc. Stamm calls this an "adsorption compression" of 0.02 cc. This does not seem an altogether happy term to use because it rather prejudges the result of inquiry into the matter of how this disappearance of volume comes about. But there is no question that volume does disappear.

The analogy between conditions where water and cellulose are brought together and those which govern ordinary solutions is not new, though this analogy may now be carried further with the greater wealth of experimental data. It is probably true that the underlying physical laws are the same in both cases. The van der Waals' factors of attraction and of molecular volume play their parts in both cases. But with cellulose we have solid structures which remain solid and these must also play a part which requires consideration. Our present task is to speculate as to the mechanism of the phenomena observed with a view to arriving at a mental picture sufficiently clear and detailed to be of help in predicting what is likely in any new set of conditions.

Our speculations may start from either end of the chain of phenomena. We may look at the external evidence and speculate as to what conditions could account for this or we can go a long way back and picture what conditions should arise if certain assumptions are made and check these imagined conditions with the evidence at hand. In neither case do we arrive at absolute proof. The most we can expect is to improve the circumstantial evidence in the case and, perhaps, have our attention drawn to gaps in our knowledge which we can fill in by planned experiment.

All natural cellulose is produced as a result of some reaction in a watery medium, usually in plant cells. We do not know this reaction in any detail but it is almost certainly a matter of adding groups to one or both ends of a growing chain. The groups added must bear some close resemblance to glucose because they definitely become glucose groups after addition. We know that, in any one region of the native cell, there is a considerable degree of parallelism of these long-chain molecules, though the direction may change from part to part of the cell. Possibly the direction is determined by the direction of flow of the cell fluids as growth takes place and this varies at different times dependent on the growth conditions of moisture, light, nutriment, and the like. There is evidence that stresses imposed on the growing part may alter the general direction of the molecular chains. This is shown by the cells in "rot-holz" or "compression wood" where the chains tend to be more than normally disposed at right angles to fiber length, apparently in response to compressive stress.

At some stage, or perhaps intermittently, these more or less parallel molecules in their mother liquor approach each other, and their units, the glucose or C_6 groups, tend to arrange themselves in a definite crystal pattern. As the molecular chains are of no fixed length and, presumably of no common starting point, such crystallization regions must be intermittent along the chain. On some chains there will be regions where there is no corresponding chain to fit in to make the crystal structure complete. In such case there will be a gap in the crystal structure. Such gaps will vary in size according to whether few or many molecules happen to pass through a particular region. Consequently the bundle of parallel molecules will be crystallized in a variety of degrees along its length. The question arises as to how many of these molecules must be grouped together in orderly fashion before the group may be called a crystal. Is a group of 3 a crystal? of 5? of 10? Where do we draw the line and say all groupings of less than some definite number of molecules must be considered amorphous and all groupings of more than this number are crystals?

It is to be expected that such a continuous group of parallel molecules would tend to have one crystal system throughout its length but it would have in it a considerable number of gaps, or places where one or more molecules would be missing from the structure. The surfaces of cellulose on the inside of the gap might or might not be accessible from the outside. If the gap was completely surrounded by well-crystallized cellulose, it would not be able to lose the water or watery solution from which the cellulose was origi-

nally deposited. Investigations (*9*) indicate that water alone, or even moderately concentrated caustic soda solutions, cannot penetrate into cellulose crystals. Any water inclusions in the structure, therefore, would be permanently trapped. In the paper on the electron microscope examination of cellulose by Barnes and Burton (*2*), there is mention of a phenomenon which may have a bearing on this point. It is stated that, when the electron stream first impinges on the cellulose, which has already been thoroughly dried under vacuum, the cellulose appears to explode at various points. Such explosions soon stop however. It may well be that these are due to the electron stream causing such water-filled pockets to burst through the structure enclosing them.

Although a few such imperfections in crystal structure may not reach the surface, it is to be expected that many more will do so. These, too, will be filled with water or watery solution while the fiber is still undried but such water can evaporate when drying eventually takes place.

However, all the cellulose deposited in one layer of the natural fiber will not come down in a single unit of linked crystal regions such as described. Alongside it will be other similar and parallel units which differ only in that the "seed" of the crystal growth happens to be rotated with respect to the first. When two such growths meet there will be a layer of imperfectly crystallized material making a transition between one crystal structure and its neighbor. Here again there must be frequent gaps due to the poorness of fit. And these too will be filled with water. But in the one layer of the fiber the general direction of molecule lengths will be parallel to each other.

When later layers are deposited, the direction of flow of the protoplasmic fluids may be different. In such case the molecular lengths will lie at an angle to those in the previous layer. Again there will be discontinuities of imperfect fit. Taking the fiber as a whole, therefore, there will be at least three regional types of imperfect fit, not including those due to inclusions of noncellulose material: (a) gaps in otherwise perfect crystals, (b) gaps due to lack of orientation between parallel or nearly parallel crystals, and (c) gaps due to layers of crystalline material passing each other at an angle. All such gaps are, in the first instance (i.e., when the fiber is first formed) filled with water. The fiber, in other words, is saturated.

This condition must be considered the natural, unstrained condition of cellulose. It is not swollen and it should be looked upon as not yet structurally deformed by shrinkage.

On removal of water, some of the elements of this structure can come closer to each other without being appreciably strained, at least in the early stages. The various crystalline groups can move toward each other as the water between them lessens. This need entail no bending of the structural units and hence no strain. But such shrinkage without the introduction of strain is limited in extent. Much more frequently it will happen that the internal tensile forces in the liquid held in the minute spaces will be sufficient to draw the solid faces of the space toward each other and thus introduce strains and corresponding stresses in the solid elements. As such stresses increase, either of two things may happen. The solid may resist the stress, letting the liquid break away so that the remaining liquid evaporates as from single surfaces. Or the liquid stresses may eventually draw opposing surfaces together, whereupon they adhere by their own crystallizing or van der Waals' forces. But it is to be noted that, in the latter case, the solid has been set in a stressed condition.

It is to this stressed condition of dried cellulose we must look for an explanation of the swelling when the dried material is again exposed to water or other liquid in which it swells. The first liquid sorbed from the low pressure vapor covers all available surfaces of the cellulose. As the data of Purves and his associates show, the available surface at this stage is comparatively small. (This evidence will be briefly discussed later.) Following this first sorption of single liquid molecules which entails no or only very slight swelling, there is further sorption on new surfaces made available by solution of cellulose-to-cellulose bonds. The first of such bonds to be replaced by cellulose-to-water-to-cellulose bonds will be those where the cellulose structure is most strained. At such places the attraction between the solid units is greatly weakened by the counter-stress in the solid structure and the solvent effect of water is aided by this stress.

The low relative vapor pressure at this stage indicates a high internal tension of the liquid water. On a completely solid or crystalline material, such as the titanium dioxide used by Harkins and Jura (*7*), this stress may be looked upon as the stress between the attraction of the solid tending to hold the vapor molecule to the surface and the attraction of empty or nearly empty space tending to cause evaporation. Cellulose, with a multitude of potential or actual surfaces practically in contact, presents opportunity for two cellulose surfaces to be in contact with a single water molecule and thus to cooperate in holding it against evaporation. But in so doing the surfaces are held together by a force which can be computed from the relative vapor pressure (RVP). As the RVP is increased, more and more water is sorbed and its internal tension is less. The forces contracting the structure are decreased and expansion takes place.

The internal tension of liquids under reduced vapor pressure is a rather difficult condition to visualize. It is, however, readily calculated by methods commonly used in thermodynamic work, the formula being

$$P = -1.94 \times 10^5 \frac{T\rho}{M} \log_{10} p_r, \qquad (3)$$

where P is the internal tension in grams per square centimeter; T is the absolute temperature; ρ is the density of the liquid in grams per cubic centimeter; M is the molecular weight of the liquid, and $\log_{10} p_r$ is the log to base 10 of the relative vapor pressure, p/p_0. For water at 20°C. and taking the density as 1.0 and calling 1000 grams/sq. cm. one atmosphere, the formula reduces to

$$P = -3170 \log_{10} p_r \qquad (4)$$

To visualize the tension idea, the simplest example is that of a capillary tube in which liquid is drawn

up by surface tension. The atmospheric pressure is practically the same at the free liquid surface and at the liquid meniscus. Therefore, immediately below the meniscus the liquid must be at a lower pressure corresponding to the height of the liquid column in the tube. It should be realized, however, that this internal tension or, more properly speaking, drop in internal pressure is not necessarily dependent on surface tension but is directly related to the lowered relative vapor pressure.

There can be little doubt about the existence of these liquid tension forces or about the possibility of cellulose bonding with itself when contacting surfaces are dried from a liquid in which it swells. The latter phenomenon is the fundamental property of cellulose which makes paper possible. Whether the combination of internal liquid tension forces and the bonding of cellulose surfaces accounts completely for the phenomena of cellulose sorption and related effects is somewhat more speculative. Yet some evidence does exist.

It is known that methyl alcohol, though it swells cellulose and does dissolve cellulose-to-cellulose bonds, does not have as great an effect on such bonds as does water. For example, a particular paper sample which had a tensile strength of 7.28 kg. when dry, showed only 0.69 kg. when wet with water. Wetting had destroyed nearly all bonding. But when the same paper was thoroughly wetted with methyl alcohol it had a tensile strength of 2.32 kg. Higher alcohols showed less reduction of tensile strength (*11*). The heat of wetting of several samples of cellulose by methyl alcohol was shown to be quite consistently about 70% of that of wetting by water (*10*). This latter may mean either less development of surface by solution of bonds or less energy of sorption. Probably both effects contribute to the over-all result.

But the sorption experiments of Russell (*11*) show that, even on a weight basis, the amount of methyl alcohol held by cellulose exceeds that of water held at the same relative vapor pressure over the greater part of the curve of desorption from saturation. Only in a short part of the ranges (above RVP = 0.80) does the amount of water exceed that of alcohol. On a volume basis the difference is, of course, greater. This is hardly to be expected if one considers only the relative affinities of alcohol and water for cellulose as shown by heat of wetting or by weakening of paper. When the data are plotted as volume sorbed against the internal liquid tension, however, the two curves agree over most of the region within the limits of experimental error. On the theory given, they cannot be expected to agree in the region near saturation for in this region the cellulose-to-cellulose bonds are those which have little residual stress and are consequently less readily dissolved by the alcohol and thus the amount of alcohol sorbed in this region is less. But the agreement of the curves over the rest of the range of desorption gives good support to the idea that the factor governing the amount of swelling and with it the amount of sorption is the internal tension.

The question of sorption mechanism is quite sufficiently complicated when nonswelling solids are involved. When the area of available surface is continually varying, as it is when water is sorbed on cellulose, the matter is far from simple. That the available surface is variable in the case of cellulose is very clearly shown in the work of Purves and his associates. In work along this line Purves (*1*) used a technique involving thallous ethylate. In this technique, the thallous ethylate is dissolved in an organic solvent and is made to react with dry or nearly dry cellulose to produce thallium cellulose compounds on the available cellulose surface. Treatment with methyl iodide is then used to alter the thallium compounds to methylcellulose. A determination of the degree of methylation then permits the calculation of the amount of cellulose surface which has reacted and, hence, is the surface available to the organic liquid solution of thallous ethylate. Purves found that, if the reaction was applied to cellulose fibers dried from water in the normal way, only a small amount of surface was available. For instance, dried cotton linters showed 8 sq. m. and dried ramie 5 sq. m. per gram. Similar material swollen with caustic soda solution and dried by solvent exchange with methanol showed surfaces of the order of 300 to 400 sq. m. per gram. This is rather definite indication of cellulose bonds being destroyed or dissolved by swelling.

The effects of variable surface are shown in an interesting way in a study by Morrison (*10*) of the heat evolved in the mercerizing process. When cellulose is wetted by water there is a considerable evolution of heat. When it is wetted by solutions of caustic soda there is a still greater heat evolution, which is especially marked when the concentration of the caustic is great enough to produce mercerization. When caustic soda solution acts on cellulose, two effects are produced. One is due to whatever chemical reactions take place and the other to the simple wetting of the surfaces of the cellulose which may be considered a physical reaction. Morrison was able to separate the heat effects of these two reactions. Using a caustic soda solution of a definite concentration, he measured the heat evolved when a standard cellulose was immersed in it. This heat included that of the wetting of the cellulose surfaces and also that involved in producing the permanent changes which may be included under the term mercerization. Then he washed out the alkali with water and dried the cellulose. He then repeated the measurement of heat evolved when this "mercerized" cellulose was immersed in caustic solution of the same strength as before. This time the heat evolved was due only to the wetting of the cellulose, since the permanent changes had been made previously. He found that the second measurement consistently showed more heat evolution than the first. This indicated that the permanent changes involved in mercerization consumed heat and that the net production of heat in both cases was due to more heat being produced by the wetting than was consumed in effecting the permanent effects of mercerization. As these latter effects are known to be mainly the production of more surface and, hence, disruption of cellulose-to-cellulose bonds, this negative heat effect is what one would expect. There is, however, the change from one crystal structure to another and there is no information as to what heat effects are involved in this.

The matter of the specific volume of cellulose involves the question of cellulose surfaces and their relationship with water. When the specific volume of standard cellulose is determined in organic liquids, it is found to be about 0.647; in helium it is 0.64; in water it is 0.62. Any one of these may be considered the "true" value. That is a matter of definition. What concerns us here is why there is a differance.

The difference between the values for organic liquids and helium can be readily explained on the basis of the relative volumes of molecules of helium and of organic liquids. The latter, being larger, cannot be expected to penetrate all the spaces which can be reached by helium. But this explanation cannot be extended to explain the difference in the values for helium and for water, because the helium molecule is smaller than that of water. The first explanation was that given by Davidson (*5*), who made the first of such measurements. He ascribed it to compression of the water layer caused by the intense attraction of cellulose for water. There is no doubt that a very considerable attractive force does exist. And, according to some theories of sorption, vapors sorbed on solids are quite dense in the layers next the solid and are progressively less dense toward the vapor phase. Davidson, assuming that the whole of the water sorbed by cotton was involved in this compression, calculated the loss of volume as about 0.02 cc. per 0.20 cc. of total water or about 10% of the water volume. This calls for a compressive force of about 3000 atmospheres. This was obviously incorrect for, even by the theories of sorption on which this compression idea was based, only those layers next the solid are under pressure and this pressure diminishes outwardly until finally the vapor phase is reached. Consequently, only a fraction of the total water is compressed and the total compressive force is correspondingly increased.

Filby and Maass (*6*) made measurements of the specific volume in helium of cellulose containing small amounts of sorbed water. From these measurements it appeared that the specific volume of the first few per cent of water sorbed was about 0.4 cc./gram. Taylor (*14*) later repeated this work with apparatus of greater precision and found that the apparent specific volume of the first water sorbed was 0.53 and that, as more water was put on the cellulose, it had more nearly its normal volume. By the time sorption reached 3.0%, the water then going on had a specific volume of 0.94. The average specific volume of the whole 3% of water was about 0.70.

These values of the specific volume of the sorbed water would call for fantastic pressures. It is probably true that the attraction between cellulose and water is greater than that between water and water. The latent heat of evaporation of water at 20°C. is 584 calories per gram. The latent heat of condensation of the first water on cellulose is about 260 calories per gram greater than this. These values would indicate that the attraction of cellulose for water would be about 50% greater than that of water for water. The internal pressure of water due to such attraction is of the order of 20,000 atmospheres. So that the extra attraction of cellulose would correspond to about 10,000 atmospheres available for compression. Such a pressure would reduce the volume to about 0.80, which is not sufficient to account for the experimental result.

Another way of looking at the matter is to consider that the water immediately in contact with the cellulose becomes, in effect, part of the solid. In this case its volume would be lower than that of normal water since the molecules would be less free to vibrate and so occupy less space. This would correspond to the reduction in volume which normally accompanies freezing of liquids. Water, freezing to ordinary ice, is an exception to this general rule but here it would not freeze to ordinary ice. Calculations based on this idea also lead to approximately 0.80 as the specific volume of this water layer, though this is not very definite.

If we again try to visualize what must take place as cellulose dries from its saturated state, we may get some idea of conditions which account for the apparent abnormal density of the sorbed water. In the saturated state we must expect that the cellulose molecules and crystals are without stress. As water is evaporated, crystals and cellulose molecules are drawn closer together by the internal tension of the water which corresponds to the lowered vapor pressure. But this drawing together of the cellulose elements does not draw the whole into a single perfect crystal. Imperfections of orientation lead to gaps. Some of these become so closely sealed off that pockets or voids are formed. And it is conceivable that, in many cases, these are not reachable even by helium any more than is the interior of the cellulose crystal. The molecule of helium, although smaller than that of water, is not very much smaller. In a volume determination in helium these voids will count as cellulose volume. But in a volume determination in water, the bonding which has sealed these voids is dissolved and they no longer count as cellulose for they become filled with water.

The interior surface of such voids must have some water sorbed on it because water must be present when sealing takes place. This water may account for the "explosions" noted by Barnes and Burton already mentioned. It must also be realized that we probably are never able completely to free even the completely accessible cellulose from water. Thus Russell (*11*) found that cellulose dried to constant weight in high vacuum over phosphorus pentoxide lost about 0.4% of its weight when heated to 100°C. in the same vacuum. Moreover, it regained this weight when cooled again. This regain must have come from the water which had been picked up by the pentoxide. (The phenomenon is called to the attention of those interested in intensive drying.)

Another experiment of interest may be cited. When cellulose saturated with water is washed repeatedly with acetone or other nonswelling liquid until no more water is removed, it has an apparent specific volume in the acetone which is even less than that shown in water. But when the acetone is evaporated, it is found that there has been a gain in weight. A natural interpretation is that some acetone has been trapped in the cellulose structure. The additional weight can be readily removed if a few per cent of water is added

to the cellulose and the drying repeated. The interesting point is that during this second drying, when we might expect to remove the trapped acetone together with the added water, nothing comes off but water. Apparently what we have trapped is not acetone but water. And thus we have the curious condition of water held on cellulose so firmly that it cannot be removed at 100°C. by a current of air dried over phosphorus pentoxide but is readily removed if some additional water be added before the drying. This curious state of affairs was observed by C. Soley and reported in his thesis work at McGill University (not published). The phenomenon has since been checked in our institute by F. H. Yorston.

This curious behavior may have at least two possible interpretations. It may mean that some water—over the normal amounts—is trapped on the interior of voids as described previously. Or it may mean that evaporation of the acetone instead of water leaves much more assessible surface and that this added water is only more of the same type that Russell found was so tenacious. On adding extra water and again drying, this additional surface is lost by the formation of cellulose-to-cellulose bonds.

CONCLUSION

The purpose of this paper is primarily to form a starting point for a general discussion of cellulose-water relationships. It is not intended to be a complete review of all data pertinent to such relationships.

One general text or theme is stressed to some extent—the part that internal liquid tension must play in the phenomena of drying and of sorption in cellulose and, hence, in the availability of cellulose surfaces. The importance of such surfaces for all cellulose uses is obvious to all who are concerned with such uses whether these are chemical or physical. No attempt has been made to extend the field of discussion beyond natural fibers, though it is felt that much of the same considerations apply. In fact, since preparation of the paper began, there has appeared an excellent paper by Roseveare, Waller, and Wilson (*12*), along much the same lines dealing with regenerated celluloses. In regenerated cellulose the crystallization has not the same factor of orientation at the time of origin and, consequently, there is much more diversity of crystal direction. These authors have not taken into consideration the effects of liquid tension on the structure, however.

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Economical Shapes for Fiber Cases

T. J. NELSON

The validity of a 2:1:2 ratio, which in recent years has received prominence as the optimum for length, width, and height, was verified by the author. An alternate ratio of 2:1:1 is discussed as a compromise between board economy and good handling characteristics. Both the 2:1:2 and the 2:1:1 ratios give cases more economical in design than a cubical case.

In the latter part of the recent war years (1943–1945) the shortage of fiber shipping cases was a matter of great concern to manufacturers and case-users alike. Reuse programs were inaugurated, and attention was focused on case designs that required less board area for a given load of merchandise. Usually this interest resulted in using larger cases with larger loads, and thereby reducing the board area per unit of contents. This measure sometimes reflected adversely on the outturns at destination, for obvious reasons.

Another method of approaching this problem of the board shortage consisted of reshaping the case in instances where the nature of the contents permitted rearranging the existing load. Here the interest ranged in form from advocation of the traditional cubical shape, to the advocation of a concept that length, width, and height should be in the ratio of 2:1:2. This 2:1:2 ratio first came to this writer's attention in a news item in 1944 (*1*), and since it was not accompanied at the time by supporting evidence, and was contrary to the traditional cube concept, calculations on both seemed desirable before using either one in a practical problem. Meanwhile the 2:1:2 ratio was suddenly being advocated in various form (*2*), (*3*), with the cube as second choice.

A series of calculations were made, therefore, to obtain the "best" shape for each of three common styles of cases:

Common or regular slotted container ("RSC") with taped manufacturer's joint.

RSC case with stitched joint.

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Table I. Fiber Shipping Cases: Shape of Case vs. Volume

Basis of Calculations: 1000 Square Inches of Available Board Area

Choice of case shape		*Regular slotted cases (taped; no side-joint tab)* — *Without collar*	*With collar*	*RSC stitched case; 2 in. side-joint; no collar*
Most economical shape of all	=	15 × 7 × 15 3/4	14 3/4 × 7 1/2 × 7 1/2	16 × 7 × 13 13/16
Corresponding volume	=	1652 cu. in.	827 cu. in.	1549 cu. in.
Most economical pliable case	=	18 3/4 × 9 × 9	(see above)	17 3/4 × 9 × 9
Corresponding volume	=	1521	....	1439
% vol. of best shape	=	92%	....	93%
Size of typical "square" case	=	12 × 12 × 8 13/16	10 × 10 × 7 1/2	12 × 12 × 8
Corresponding volume	=	1271	750	1152
% vol. of best shape	=	77%	91%	75%
Size of typical "cube"	=	11 × 11 × 11 11/16	9 × 9 × 9 3/8	11 × 11 × 10 3/4
Corresponding volume	=	1420	759	1300
% vol. of best shape	=	86%	92%	84%

RSC case, with taped joint, reinforced with a collar or extra vertical wall lining the inside perimeter of the case.

The results of these three sets of calculations were plotted in curve form, and the optimum case-volumes obtainable with a given area of board (1000 square inches) were noted.

The 2:1:2 ratio was confirmed rather closely as being the most economical shape for a plain RSC case from a board-area standpoint. The calculations also gave an interesting 2:1:1 ratio (approximately) for a conventional right-side-up case that has since proved both economical and highly practical in a number of applications during and since the war. This 2:1:1 ratio often lends itself to easy adaptation to conventional filling lines and sealing lines in the user's plant, and also has points of superiority over the tall 2:1:2 case in later palletizing merchandise and in general shipment and warehousing.

(The 2:1:2 case being tall and narrow, will commonly be laid over on its side; it then becomes the end opening, or "end-flap" case (*2*) and this introduces complications in the instance of some products. The contents may not carry well when laid down, and in addition the rigidity of the case board and of the folded score-lines thus brought into play may be impaired. The printing may also be difficult to read. On the contrary, if the tall case is not turned over, its height lends to instability, in pallet loads for example.)

It is true that measures can be taken to overcome these points of inferiority of the 2:1:2 case. For example, (*4*) with corrugated board, the rectangular blank from which the case is formed can be so cut and slotted that the arches are reversed in direction and the inner case flaps are made wider—all with the objective of obtaining substantially normal resistance to compression in warehouse piles built with the 2:1:2 case laid on its side. Suitable rearranging of the printing will also give a 100% normal appearance when laid down, even as regards appearance of the end flaps forming the end panel of the case.

Such measures, however, may add to case manufacturing costs, and may leave some unsolved questions, like unconventional filling and the horizontal position of the contents after filling.

DATA ON OPTIMUM CASE SHAPES

The tabulation following herewith is based on three sets of calculations, dealing respectively with: RSC cases taped; RSC cases, taped and with an internal collar around the four walls; and RSC cases, stitched. Each set of calculations involved as many as 75 to 100 separate examples which were worked (in lieu of resort to higher mathematics) to permit plotting a series of "volume vs. shape" curves. By selecting the best point on the best curve (or by interpolation between two curves) the approximate ideal shape was selected.

It will be noted that the basis of the calculations is 1000 square inches of board, and the volume obtainable therewith. Also, the ideal dimensions shown permit of some choice as to practical application, since curves show that volume changes are very small in the vicinity of the dimensions indicated.

Attention is also called to the fact that several assumptions were made to expedite the calculations; these were:

1. No allowances for board used around case corners, nor for volume lost due to thickness of collar (where used).
2. Allowance for a 2-inch side joint tab (Rule 41 (*5*) specifies not less than 1 1/4 inches).
3. Board area is the criterion; manufacturing costs and other aspects are not involved in choices except as indicated.
4. Dimensions are given to nearest sixteenth of calculated decimal values obtained.

To apply these figures to a given problem, having a known volume of commodity, it is first necessary to obtain the cube root of the ratio between the known volume and the tabulated volume. By dividing (or multiplying) this cube root by the respective *tabulated dimensions,* the dimensions of the given problem-case are obtained.

Solution of a given problem can also be performed by the trial-and-error method, if dimensions used approximate the intended ratio. Results will be reasonably close to the optimum, since it was established that negligible changes in volume occurred when near-by sets of dimensions were used.

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Bleaching Groundwood Pulps with Hypochlorites

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Results of bleaching experiments made at the Forest Products Laboratory on groundwood pulps from 13 hardwoods, 6 softwoods, and a mixture of 6 hardwoods alone and in mixture with Eastern white pine, show that calcium hypochlorite is a satisfactory bleaching agent for the hardwood pulps, but probably is not for the softwood pulp. In general, the brightness of the hardwood pulps was increased to the range of 70 to 79% with 10% available chlorine. Upon exposure to carbon arc light, the recession in brightness ranged from 4 to 11 points. Bleached pulp yields were 98 to 100% of the unbleached pulp. The only consistent effect of the bleaching on drainage and strength properties was an increase in tensile strength. In order to get a good bleaching effect with hypochlorite, its tendency to react very rapidly with groundwood pulp must be retarded considerably, especially at the start of the reaction. This was done by use of low density, low temperature, and a high alkalinity, with the latter being the most critical of the three. The lime requirement for control of alkalinity ranged from 3 to 6%, including the free lime in the bleaching liquor. Substitution of sodium silicate for a part of the lime in the bleaching of some pulps further improved brightness up to 5 points. Final addition of sulphurous acid, or equivalent, to the stock had a similar effect. Although the hue of hypochlorite-bleached pulps was in the yellow range, in the case of hardwood pulps, it is believed to be light enough to be generally satisfactory. Experimental results indicated that pulps from mixtures of hardwoods can be bleached satisfactorily with hypochlorite and that the brightness of the mixtures will be proportional to that obtainable on pulps from the individual woods. Although the Eastern white pine pulp did not respond satisfactorily to hypochlorite, a 50-50 mixture of it and the mixed hardwood pulp was bleached to about 70 brightness with 10% available chlorine. Essentially the same result was obtained, however, by blending bleached mixed hardwood pulp with unbleached pine pulp. This procedure would be the more economical of the two.

THE DESIRABILITY of a practical bleaching treatment to enable the use of groundwoods for whiter papers is well recognized. Requirements for such a treatment are that its chemical cost will be low, that it will effect an appreciable increase in brightness that will not recede too rapidly, that it will not develop a strong yellow hue, and, finally, that it will cause only a small loss in weight of pulp by chemical action. It appears that no one bleaching process meets these requirements for all groundwood pulps. The most promising agents for the commercial bleaching of groundwood pulps are hydrosulphites, peroxides, and hypochlorites (*1, 4, 6, 7*).

Although the purpose of the present paper is to illustrate the possibilities of hypochlorites, chiefly calcium, for bleaching groundwood pulps, brightness values obtained with sodium peroxide have been included as a measure of the effectiveness of the hypochlorites.

The rate of reaction between calcium or sodium hypochlorite and groundwood with 10% available chlorine is normally extremely rapid. For a satisfactory result in any instance, the density, temperature, and alkalinity must be adjusted so that the rate of reaction will be definitely retarded at the start. It appears, however, that the alkalinity is the most critical of the three variables. In general, density should not exceed 6%, and no apparent benefit was observed for lower values. Temperature does not need to exceed 30°C., and alkalinity should be equivalent initially to the pH range of 11 to 12 and, at the end of the reaction, to not less than pH 8. Examples of the influence of alkalinity and the use of sodium silicate in the buffer system are given in a previous publication (*4*). Depending on the pulp, the use of sodium silicate as a part of the buffer system will give a somewhat better brightness than otherwise. It further appears that the reaction should be stopped a little short of complete chlorine consumption in order to realize the maximum brightness. The addition of sulphur dioxide at the end of the reaction is usually beneficial to brightness, but it does not improve its stability.

EFFECTS OF BLEACHING

Brightness

The brightness of the hardwood pulps reported on here was increased from 8 to 23 points with calcium hypochlorite at the level of 10% available chlorine. It is shown in Table I that those increases resulted in brightness values of 70 to 79% for the bleached pulps. In some instances, with, for example, the sugar maple and sweetgum pulps, sodium hypochlorite gave from 4 to 8 points higher brightness values than calcium hypochlorite. In general, calcium hypochlorite gave higher brightness values for the hardwood groundwood pulps than did sodium peroxide under the condition used.

Pulps made from two different lots each of quaking aspen, paper birch, yellow poplar, and sugar maple woods were studied to note possible variations within species. Although little difference was observed between the lots of aspen and paper birch, the results obtained for the yellow poplar and sugar maple pulps indicate that variation within some species is to be expected. The experience with the two lots of yellow poplar was especially interesting. The fresh pulp from lot II in its natural condition did not respond to hypochlorite nor to sodium peroxide. When the pulp was extracted with alcohol, however, either before or after treatment with 10% chlorine as calcium hypochlorite, a brightness increase of 7 points resulted. The alcohol

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removed a yellow-colored material. After a portion of the unextracted pulp at about 25% density had been in storage about fifty days at 5°C., it did not respond to hypochlorite, but another portion at the same density after storage at room temperature during the same period did respond to the extent of 11 points increase in brightness.

No difficulty was experienced in bleaching a pulp from a mixture of hardwoods comprising 29% each of red maple and paper birch, 16% each sugar maple and yellow birch, and 5% each of white ash and American beech by weight. On a volume basis, the percentage values were essentially the same as on the weight basis because of the similarity of the specific gravities. The optimum conditions for calcium hypochlorite bleaching were the same as for the other hardwood pulps. When a brightness value was calculated for the mixture on the basis of direct proportionality from the experimental brightness values for the bleached pulps from the individual woods, the calculated value agreed with the value determined experimentally. Although pulps from two of the component woods, white ash and American beech, contained numerous shives that were not bleached satisfactorily, there was no evidence of unbleached shives in the bleached pulp from the mixture.

The brightness values obtained for the softwood mechanical pulps indicate that, as a class, they do not respond well to hypochlorites. Of five softwood pulps, only a white spruce pulp reached a brightness value possibly of practical significance when treated with 10% available chlorine as calcium hypochlorite. With sodium hypochlorite equivalent to 10% chlorine, a southern yellow pine pulp reached only 63 brightness, the increase being 8.5 points. The Eastern white pine pulp required 15% chlorine as calcium hypochlorite for a brightness approaching 70, and even then the bleached pulp was quite yellow in hue.

The use of silicate in conjunction with lime as the buffer system with calcium hypochlorite gave no improvement in the brightness of the Eastern white pine pulp. The use of sodium hypochlorite or extractions with hot water, sodium hydroxide, or hydrochloric acid had little effect. Extraction with alcohol, how-

Table I. Influence of Hypochlorites and Sodium Peroxide on Appearance and Yield of Groundwood Pulps

Species	Bleaching agent[a] Kind	Amount, %	Stock density, %	Temperature, °C.	Alkalinity Initial pH	Alkalinity Final pH	Duration of treatment Hr.	Min.	Brightness[b] Unbleached pulp, %	Brightness[b] Bleached pulp, %	Dominant wavelength Unbleached pulp, mmu	Dominant wavelength Bleached pulp, mmu	Purity Unbleached pulp, %	Purity Bleached pulp, %	Yield of bleached pulp,[c] %
Hardwoods															
Sweetgum	$Ca(OCl)_2$	10	6	35	10.7	8.6	1	7	53.5	74.1	...	...	..	..	98.8
	Na_2O_2	2	12	40	10.4	9.0	2	0	53.5	72.6	...	...	..	..	100.0
Black tupelo	$Ca(OCl)_2$	10	6	36	10.9	10.0	..	40	61.3	72.5	...	...	..	..	98.8
	Na_2O_2	2	12	41	10.3	9.2	2	30	61.3	65.7	...	...	..	..	97.5
Water tupelo	$Ca(OCl)_2$	10	6	35	11.3	8.2	1	8	66.0	73.9	...	...	..	..	99.3
	Na_2O_2	2	12	40	10.5	9.2	2	15	66.0	76.6	...	...	..	..	100.0
Yellow poplar I	$Ca(OCl)_2$	10	6	37	11.1	8.9	1	0	61.0	72.0	...	...	..	..	98.8
	Na_2O_2	2	12	41	10.3	8.5	4	0	61.0	70.3	...	...	..	..	99.0
Yellow poplar II	$Ca(OCl)_2$	10	6	37	11.7	8.3	1	0	61.3	63.0[d]	578.2	576.5	10.5	16.1	..
	Na_2O_2	2	12	40	10.3	9.2	1	0	61.3	60.5	578.2	577.5	10.5	13.6	...
Eastern cottonwood	$Ca(OCl)_2$	10	6	34	11.4	10.0	..	40	52.2	71.2[e]	580.4	576.5	13.5	9.9	99.2
	Na_2O_2	2	12	42	10.7	9.7	1	0	52.2	66.7	580.4	577.2	13.5	10.2	97.3
Quaking aspen I	$Ca(OCl)_2$	10	6	35	11.2	8.5	..	55	63.4	75.7	...	...	...	..	99.2
	Na_2O_2	2	12	40	10.5	8.7	2	0	63.4	77.0	...	...	..	..	97.9
Quaking aspen II	$Ca(OCl)_2$	10	6	27	11.0	8.4	2	30	63.5	76.0	576.5	573.5	9.9	7.9	...
	Na_2O_2	2	12	40	10.3	8.5	2	45	63.5	76.9	576.5	577.0	9.9	6.0	...
Paper birch I	$Ca(OCl)_2$	10	6	36	10.5	8.9	..	47	59.0	75.0[e]	...	578.2	..	11.3	...
	Na_2O_2	2	12	41	10.2	8.5	2	0	59.0	75.6	...	579.5	..	8.7	98.0
Paper birch II	$Ca(OCl)_2$	10	6	30	12.0	8.8	2	52	56.3	79.0	578.8	575.0	14.3	8.3	...
	Na_2O_2	2	28	42	10.3	8.8	..	30	56.3	76.1	578.8	579.5	14.3	8.7	98.6
Yellow birch	$Ca(OCl)_2$	10	3	32	11.9	8.4	2	45	53.8	76.7[e]	581.2	575.0	12.0	8.7	99.7
	Na_2O_2	2	28	41	10.3	9.0	..	20	53.8	66.9	581.2	580.0	12.0	10.5	98.6
Sugar maple I	$Ca(OCl)_2$	10	6	36	11.0	10.1	..	20	49.5	66.0[e]	581.3	570.0	15.7	6.0	...
	NaOCl	10	6	35	11.4	9.2	..	40	49.5	71.3	581.3	575.3	15.7	6.4	...
	NaOCl[f]	10	6	35	11.2	9.0	1	0	49.5	74.2	581.3	576.7	15.7	9.1	...
	Na_2O_2	2	12	44	10.5	9.3	1	0	49.5	55.0	581.3	580.0	15.7	12.4	96.2
Sugar maple II	$Ca(OCl)_2$	10	6	31	12.3	8.6	2	0	57.9	78.6[e]	581.2	577.1	12.0	7.6	97.3
	Na_2O_2	2	12	41	10.3	9.1	1	0	57.9	71.4	581.2	577.5	12.0	6.0	99.8
	Na_2O_2	2	28	42	10.4	9.3	..	40	57.9	73.9	581.2	574.4	12.0	7.6	98.9
Red maple	$Ca(OCl)_2$	10	6	30	12.0	8.3	1	45	57.6	78.9[e]	580.0	575.0	10.5	8.3	99.3
	Na_2O_2	2	28	39	10.6	9.2	..	45	57.6	72.6	580.0	577.8	10.5	8.4	99.4
Ash, white	$Ca(OCl)_2$	10	6	31	11.7	8.0	1	15	57.2	74.8[e]	577.3	571.4	11.3	10.0	99.8
	Na_2O_2	2	28	43	10.2	9.3	..	20	57.2	70.6	577.3	572.4	11.3	9.0	99.1
American beech	$Ca(OCl)_2$	10	6	30	11.5	8.0	1	47	49.1	72.0[e]	580.4	576.0	13.5	11.3	101.0
	Na_2O_2	2	28	40	10.3	9.8	..	30	49.1	62.0	580.4	578.2	13.5	12.1	99.4
Mixed hardwoods[g]	$Ca(OCl)_2$	10	3	30	11.6	8.3	2	15	54.5	77.2[e]	580.9	576.0	12.0	9.1	99.0
	Na_2O_2	2	28	42	10.4	10.1	..	25	54.5	70.9	580.9	576.5	12.0	9.9	99.2
Softwoods															
Eastern white pine	$Ca(OCl)_2$	10	6	31	11.2	9.9	..	33	63.5	63.4[e]	578.5	577.8	12.0	14.3	...
	$Ca(OCl)_2$	15	6	30	11.4	10.1	1	37	63.5	69.6[e]	578.5	576.5	12.0	11.4	99.4
	Na_2O_2	2	28	41	10.7	10.2	..	15	63.5	68.0	578.5	576.0	12.0	9.9	99.5
Southern yellow pine	$Ca(OCl)_2$	15	10	36	11.3	10.9	1	55	54.5	60.8	...	...	..	..	99.0
	NaOCl	10	10	36	11.4	9.1	1	50	54.5	63.0	...	...	..	..	97.6
	Na_2O_2	2	12	42	10.3	9.1	3	0	54.5	65.5	...	...	..	..	97.5
Jack pine	$Ca(OCl)_2$	15	10	36	11.3	10.2	..	20	57.1	60.6	...	...	..	..	99.3
	Na_2O_2	2	12	45	10.3	9.1	4	0	57.1	61.7	...	...	..	..	96.7
White spruce	$Ca(OCl)_2$	10	6	25	11.1	9.6	..	40	61.4	67.9[e]	...	...	..	..	100.6
	$Ca(OCl)_2$	15	6	25	11.2	7.9	2	0	61.4	74.0[e]	...	577.0	..	11.7	100.0
	Na_2O_2	2	12	40	10.4	9.6	1	30	61.4	70.9	...	561.8	..	11.1	100.0
Western hemlock	$Ca(OCl)_2$	10	6	37	10.3	9.6	..	10	48.9	45.0	580.0	579.0	15.4	20.4	98.8
	NaOCl	10	4	27	12.8	12.6	..	30	48.9	54.7[e]	580.0	...	15.4	..	98.8
	Na_2O_2	2	12	40	10.2	9.9	1	0	48.9	52.2	580.0	580.0	15.4	15.8	98.2

[a] Percentage values refer to weight of available chlorine, sodium peroxide, or other chemicals and are based on unbleached pulp. The calcium hypochlorite solution contained 0.3 to 0.7% free alkali as hydroxide and required 1 to 6% additional lime for adjusting initial pH. The sodium hypochlorite contained 3.6% free alkali as hydroxide and required up to 2% additional caustic for adjusting initial pH. The peroxide bleaching solution contained 2% sodium peroxide 5% sodium silicate, 0.05% magnesium sulphate, and up to 1.5% suphuric acid to adjust initial pH.

[b] Measured on air-dry test sheets. Except as noted, test sheets of the hypochlorite-bleached pulps were formed at pH 7.5 from pulp washed with tap water of pH 7.5. In the case of peroxide-bleached pulps a final adjustment of pH to 5 was made with sulphurous acid and the test sheets were formed at pH 5 from unwashed pulp.

[c] Based on unbleached pulp.

[d] This sample of pulp was freshly made. When bleached after 53 days' storage at room temperature the brightness obtained was 71.5%.

[e] A final adjustment of pH to 5 was made with sulphurous acid and test sheets were formed at pH 5.0 from unwashed pulp.

[f] Two per cent sodium metasilicate was added to the bleach mixture.

[g] Twenty-nine per cent each of red maple and paper birch, 16% each of sugar maple and yellow birch, and 5% each of American beech and white ash on a weight basis and essentially the same by volume.

Table II. Recession of Brightness of Bleached Groundwood Pulps upon Exposure to Carbon Arc Light

Pulp	Bleaching agent[a]	Brightness increase when bleached, points	Duration of exposure,[b] hr.	Recession, points
Paper birch I	$Ca(OCl)_2$	16.0	2	7.9
	Na_2O_2	16.6	2	8.6
Paper birch II	$Ca(OCl)_2$	22.6	1	9.9
	Na_2O_2	19.8	1	7.7
Yellow birch	$Ca(OCl)_2$	19.7	1	4.2
	Na_2O_2	13.1	1	3.3
Sugar maple I	NaOCl[c]	24.7	2	8.7
	Na_2O_2	5.5	2	4.5
Sugar maple II	$Ca(OCl)_2$	20.7	1	10.6
	Na_2O_2	16.0	1	5.3
Red maple	$Ca(OCl)_2$	21.3	1	9.1
	Na_2O_2	15.0	1	5.8
White ash	$Ca(OCl)_2$	22.4	1	6.8
	Na_2O_2	13.4	1	5.5
American beech	$Ca(OCl)_2$	22.9	1	6.4
	Na_2O_2	12.9	1	4.3
Mixed hardwood[d]	$Ca(OCl)_2$	22.7	1	7.6
	Na_2O_2	16.4	1	5.2
Eastern cottonwood	$Ca(OCl)_2$	21.0	2	8.7
	Na_2O_2	14.5	2	4.7
Eastern white pine	$Ca(OCl)_2$[e]	6.1	1	12.1
	Na_2O_2	4.5	1	2.4
White spruce	$Ca(OCl)_2$	6.5	2	13.1
	$Ca(OCl)_2$[e]	12.6	2	18.3
	Na_2O_2	9.5	2	11.5

[a] The amount of hypochlorite was 10% expressed as available chlorine, except in the two instances footnoted, and the amount of sodium peroxide was 2%.
[b] Single-arc, carbon arc light.
[c] Two per cent of sodium metasilicate was added to the bleach mixture.
[d] Twenty-nine per cent each of red maple and paper birch, 16% each of sugar maple and yellow birch, and 5% each of white ash and American beech on the weight basis.
[e] Fifteen per cent available chlorine.

ever, removed a yellow material; and when the extracted pulp was treated with 10% chlorine as calcium hypochlorite and this was followed with an final treatment with sulphurous acid, a brightness increase of 4.2 points resulted. At the present time, hypochlorites show little promise as practicable agents for bleaching softwood groundwood pulps.

Stability of Brightness

Relative stability of the brightness of the groundwood pulps after bleaching with hypochlorites is compared to that of those bleached with sodium peroxide by the recession values given in Table II. The values were obtained by exposure of test sheets to single-arc carbon arc light. Because of differences in exposure time, all pairs of pulps are not directly comparable, but it appears that the greater proportion of recession effected by carbon arc light occurs at the end of 1 hour (*5*). The data show that the brightness of the pulps after bleaching with hypochlorite was less stable than after bleaching with sodium peroxide. The hardwood pulps bleached with hypochlorite, including the mixed hardwood pulp, retained, however, 50 to 80% of the original brightness increase. Owing to a generally higher initial brightness than that of the peroxide-bleached pulps, they were at least as bright as the latter after both had been subjected to exposure.

Hue

Because of the hue of groundwood pulps, either bleached or unbleached, the brightness value alone is inadequate to characterize appearance. Consequently, the appearance of the pulps dealt with in this report is given in terms of brightness, dominant wavelength, and purity (*2*), as shown in Table I. It was previously suggested (*4*) that a yellowness value (*3*) might be a sufficient supplementary value for a numerical comparison of the appearance of bleached groundwood pulps. Further experience, however, indicates that the usefulness of the yellowness value is limited, apparently because bleached groundwood pulps are too far removed from the degree of whiteness for which the yellowness value was originally intended to be used. The amber, green, and blue filters used in the tristimulus measurements had maximum transmission values of approximately 590, 555, and 456 mmu.

The range of dominant wavelength for all pulps, both bleached and unbleached, was from 562 mmu for the hypochlorite-bleached white spruce pulp to about 582 mmu for the unbleached yellow birch and sugar maple pulps. The range for green is considered to be 500 to 570 mmu and that for yellow, 570 to 590 mmu (*2*). On that basis, the experimental pulps were all essentially yellow in hue. If 580 mmu are taken arbitrarily as yellow, the indication is that bleaching with hypochlorites consistently gives hues slightly toward the green, or lower, wavelength. With sodium peroxide the trend toward the green is, in general, the same, but the effect is slightly less. In general, the purity of hue resulting from hypochlorite bleaching appeared to be about the same as that resulting from

Table III. Change in Freeness ond Strength Resulting from Bleaching Groundwood Pulps with Hypochlorites[a]

Pulp	Bleaching agent	Freeness: Canadian standard, %	Freeness: Schopper Riegler, %	Bursting strength, %	Tearing strength, %	Tensile strength, %
Sweetgum	$Ca(OCl)_2$	− 1	−10	57	− 8	80
	NaOCl	− 4	−13	85	−14	95
Black tupelo I	$Ca(OCl)_2$	7	− 6	27	20	35
	NaOCl	−11	−11	36	22	55
Black tupelo II	$Ca(OCl)_2$	−23	− 4	−24	75	294
	NaOCl	−16	− 4	−34	42	260
Water tupelo	$Ca(OCl)_2$	−19	− 6	20	67	42
Yellow poplar I	$Ca(OCl)_2$	27	3	33	0	52
Quaking aspen I	$Ca(OCl)_2$	−35	−19	110	33	132
Quaking aspen II	$Ca(OCl)_2$	−20	−17	45	25	94
Sugar maple I	NaOCl[b]	− 3	− 3	22	5	35
Red maple	$Ca(OCl)_2$	6	− 4	19	−17	38
White ash	$Ca(OCl)_2$	−12	6	0	0	11
American beech	$Ca(OCl)_2$	14	−12	−25	11	−15
Mixed hardwood	$Ca(OCl)_2$	− 1	25	70	107	198
Eastern white pine	$Ca(OCl)_2$[c]	5	2	22	− 2	42
Southern pine	$Ca(OCl)_2$	−24	6	−83	− 8	−12
	$Ca(OCl)_2$[c]	− 3	− 3	0	..... − 8	11

[a] The amount of hypochlorite, except as noted, was 10% expressed as available chlorine.
[b] Two per cent sodium metasilicate was added to the bleach mixture.
[c] Fifteen per cent available chlorine.

Table IV. Properties of Eastern White Pine and Hardwood Groundwood Pulp Mixtures

Pulp	Brightness, %	Dominant wavelength, mmu	Purity, %	Recession of brightness,[a] points	Strength: Bursting strength (25 × 40 —500), points per lb. per rm.	Strength: Tearing strength (25 × 40 —500), g. per lb. per rm.	Tensile strength, p.s.i.	Freeness: Canadian Standard, ml.	Freeness: Schopper-Riegler, ml.
Eastern white pine									
Unbleached	63.5	578.5	12.0	4.9	0.17	0.56	1030	235	563
Bleached[b]	69.6	576.5	11.4	12.1	0.22	0.55	1460	240	590
Mixed hardwood[c]									
Unbleached	54.5	580.9	12.0	0.6	0.10	0.13	490	92	307
Bleached[d]	76.8	573.0	9.0	7.6	0.17	0.27	1463	115	303
Mixed hardwood, pine									
Bleached together[d]									
Hardwood 75, pine 25%	73.2	575.2	11.3	5.5	0.17	0.31	1095	80	360
Hardwood 50, pine 50%	69.8	575.5	12.4	5.8	0.18	0.45	1217	123	430
Hardwood 25, pine 75%	66.3	576.0	13.5	5.5	0.19	0.52	1364	177	520
Bleached mixed hardwood[d]									
Unbleached pine									
Hardwood 75, pine 25%	71.4	578.5	9.5	6.8	0.18	0.37	1140	90	375
Hardwood 50, pine 50%	68.2	579.0	10.5	6.2	0.18	0.40	1193	110	422
Hardwood 25, pine 75%	65.2	579.0	11.3	5.8	0.18	0.51	1065	168	505

[a] Exposed 1 hour to single-arc carbon arc light.
[b] Calcium hypochlorite. The amount of available chlorine was 15% based on the pulp. Bleaching conditions were: density 6%, temperature 30°C., initial pH 11.3 to 11.7 and final pH 7.2 to 10.1. Test sheets were formed at pH 5 from unwashed pulp after adjusting pH to 5 with sulphurous acid.
[c] Twenty-nine per cent each of red maple and paper birch, 16% each of sugar maple and yellow birch, and 5% each of white ash and American beech on a weight basis and essentially the same by volume.
[d] Ten per cent available chlorine, otherwise the same as in footnote *b*. Reaction times for the mixtures in the order named were 70, 65, and 60 minutes.

bleaching with sodium peroxide. The high purity values of the bleached yellow popular II (Table I), Western hemlock, and the Eastern white pine pulps after bleaching with 10% available chlorine accords well with their strong yellow appearance.

Yield

The yield values given in Table I, determined without loss of fiber, show that losses in weight due to the chemical action of calcium hypochlorite averaged 0.9%, with a maximum of 2.7%. Those results appear very favorable in comparison to those obtained with sodium peroxide.

Freeness and Strength

All of the experimental pulps were not made under grinding conditions for optimum freeness and strength. Consequently, the effect of bleaching on those properties is expressed as a percentage change in Table III.

A decrease in freeness was obtained more frequently than an increase, with the changes ranging from a negligible to an appreciable amount. Although the percentage values for changes in bursting strength were large because the bases for calculation were all small, they represent only small actual changes in points. The same was true of the changes in tearing strength. Since there was no definite trend toward higher or lower values, it is apparent that there was no significant effect of bleaching on bursting and tearing strengths.

There was a definite trend toward relatively large increases in tensile strength as a result of hypochlorite bleaching, although the tensile strength of the southern yellow pine and American beech pulps was decreased about 80 p.s.i. With those two pulps excluded, the average increase in tensile strength was 365 p.s.i., the maximum being 972 p.s.i. As previously reported (*4*), a somewhat smaller increase in tensile strength can be expected when bleaching with sodium peroxide.

HARDWOOD AND SOFTWOOD MIXTURES

The possibilities of processing mixtures of hardwoods and softwoods are of interest to manufacturers of groundwood papers. Results are given in Table IV of hypochlorite-bleaching experiments on stocks composed of mixtures of an Eastern white pine groundwood with one made from a mixture of hardwoods.

The failure of the Eastern white pine pulp to respond to a treatment of 10% available chlorine as hypochlorite, except for improvement in tensile strength, was discussed above. When mixtures of the pine and mixed hardwood pulps were treated with 10% available chlorine as calcium hypochlorite, the brightness was increased in proportion to the amount of hardwood pulp in the mixture. This is shown by the fact that the experimental values can be calculated almost exactly on a direct proportionality basis from the brightness values of the unbleached pine pulp and of the bleached mixed hardwood pulp. The indication is that when the mixture of the unbleached pine and mixed hardwood pulp was treated with hypochlorite, the effective rates at which chlorine was consumed by the two pulps were equal despite the large difference in the reaction times when the pulps were bleached separately.

In the preparation of a mixed pulp in the brightness range of 65 to 73 from Eastern white pine and mixed hardwoods of the composition dealt with here, less chlorine would be required by mixing unbleached pine pulp with hypochlorite-bleached hardwood pulp than by bleaching the mixture with hypochlorite.

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Gas-Fired Infrared or Radiant Heat Drying

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Radiant heat from suitable gas-fired units offers a means of increasing the drying capacity of present paper machines with minimum alterations and installation cost. The operating cost is much less than that for heat lamps or induction heating. A properly engineered unit, taking all factors into account, approaches and may eventually equal steam drying in cost.

DRYING—evaporation of water or organic solvent—is one of the important steps in papermaking and in many converting operations. Frequently the drier capacity is the limiting factor which holds down production and thereby reduces profits. The addition of driers to increase production involves a substantial investment and additional space which is not always available. The added driers require more power to run, and more steam to operate; this may entail additional steam generating capacity and added costs.

Textile manufacturers for many years have faced the same problems. They found that by preheating their materials before entering the drying range it was possible to get substantial increases in drying speeds with existing machines. It would appear logical since the paper and textile industries have parallel drying problems that some of the methods proved satisfactory in the textile industry may be introduced into the paper mill for moisture removal. One of the more successful methods is the application of radiant heating.

Early equipment in this field was very crude and in some cases damaged the product. The quality of foods, wood products, and some protective coatings is impaired if attempts are made to force the drying by an excessive temperature increase. The equipment has, of course, been under constant development and has made rapid strides toward perfection.

The earliest type of preheating equipment was probably the drilled pipe gas burner. The long lazy flame and low heat output of this type of burner usually rules it out for most applications. With long flames impingement generally occurs, which is apt to discolor or scorch the product even though there is no great volume of heat in the flame itself. Still, there are some processes for which this equipment is ideal.

One type of equipment which is receiving increased attention for drying web materials is the so-called infrared or radiant heat unit. There are several kinds of such heaters, and some startling claims have been made for their performance. There is a danger of one reading some of these claims jumping to the conclusion that a new era of drying practice is in prospect which is not fully justified. Properly engineered and installed radiant heaters can, however, be extremely effective.

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RADIANT HEAT

Many persons have formed the opinion that infrared is a combination of x ray and heat ray which will penetrate any material and remove water or other solvents from the interior. This is most unfortunate as this belief may lead to disillusionment and a tendency to underestimate the real value of infrared. Infrared refers to heat in wave form, the waves being of such length that they are just beyond the range of human vision. These waves are generated by a heated body and will travel through air without interruption, but when they reach a solid material, which is opaque to the waves, they generate heat upon the surface of this material. There is no mysterious penetration to the center in any appreciable amount. The heat is generated where the waves are stopped which is usually on or very near the surface.

This may not be in accordance with some of the claims made about infrared. Some of the spectacular claims of infrared performance have been backed by actual demonstration but usually are lacking in practical value. For example: there was an occasion to test the action of radiant heat (infrared) on some thick samples of wool felt. These felts were white and a half inch or more in thickness. Radiant heat was applied mildly to the surface of the felt, particular care being taken not to scorch the surface. The material was exposed to the heat for a considerable time and then torn open. It was found that, while the outer surface was still perfectly white, with no evidence of scorching, the interior had been discolored due to heat. This would seem to indicate extreme penetration. However, the time involved was so great that the operation had no practical value for drying on a production basis. The explanation, no doubt, was that heat gradually penetrated to the center of the material and could not escape, eventually building up a temperature sufficiently high to char the material while the outer surface exposed to the air was constantly cooled.

To illustrate how one can be misled by test or demonstrations, heat from radiant gas burners was applied on the outer surface of wet insulating board, about three quarters of an inch thick, at a very rapid rate. A thermocouple inserted in the center of the material was connected to an indicating pyrometer. The surface was heated so violently that it was charred, but instead of the temperature in the center of the material increasing as might be expected, the indicator dropped almost to the freezing point. It was believed that the instrument was at fault, but repeated tests had practically the same results. Apparently the terrific heat on the surface caused such a rapid withdrawal of moisture from the center that a violent evaporation was taking place while the in-

sulating qualities of the material itself prevented penetration of heat.

Then again, radiant burners applied to insulating material such as two $^1/_8$-inch sheets of asbestos glued together, traveling past the burners at a slow rate causing violent heating, has produced blistering in the center.

These examples have been cited to show that, while claims can be proved, it is highly important that common sense and experience be used in actual application for production purposes.

It will be noted that infrared or radiant heat have been referred to as one and the same. Actually, the terms are synonymous. It is believed that the term radiant heat is more generally known and less likely to cause divergence into realms of the theoretical.

The author is primarily interested in radiant heat from gas-fired burners, and feels this is the most practical type for paper-drying operations. These are pressure gas burners using porous refractories. Gas and air in a carefully proportioned mixture are delivered to the burner under pressure and burned on the surface of the refractory. This may reach 2200 to 2600°F., but the unit can be throttled back to 10% of capacity without danger of blowbacks. The burners, when properly adjusted, are practically flameless. A section of a typical burner is shown in Fig. 1.

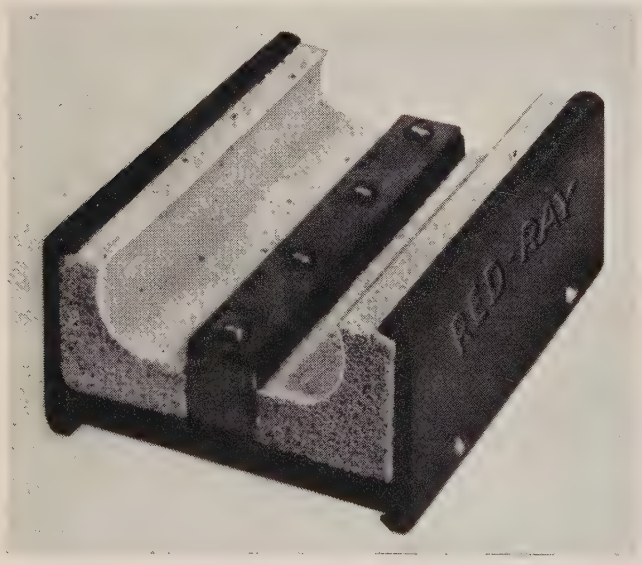

Fig. 1. A 7-inch section of radiant burner

Not all the heat generated is in the form of radiant heat. A considerable portion is in the form of heated air and hot products of combustion. Theoretically, a burner installed under material operates more efficiently. However, careful checking of results with actual installations shows very little difference in efficiency between burners located above material and those located below material. By heating the air, the moisture-absorbing capacity is increased, and this, plus hot products of combustion and radiant heat gives higher moisture removal than any other drying medium utilizing the same amount of space. In the removal of water from paper heat units are required, and a radiant gas burner will deliver more British thermal units economically in a restricted area than any other type of equipment now offered to the industry.

APPLICATIONS

When refractory temperatures of 2600°F. are applied to paper, there may be some question as to its effect on the material. Bear in mind that most installations are made on paper at the wet end of the machine where the paper contains a large percentage of moisture. As the heat is applied to the wet surface a rapid evaporation takes place absorbing the heat, and maintaining a safe temperature within the material. In a recent test, 22-point boxboard material with 70% moisture content was subjected to a radiant burner with surface temperatures of 2600°F., for 1 minute; the material was quickly removed and a thermometer wrapped up in it, and the surface temperature was found to be 140°F. In a test made on heavy kraft paper running 4 inches from the surface of one radiant burner, the material surface temperature rise was 25°F.

A recent test on light-weight, second-sheet writing paper was made with the following results. The paper was dried, then passed through a size tube and press. The sheet leaving the size press carried 40% moisture, wet basis. It was taken over a single radiant burner, and then bypassed the size driers to the calender stack, a distance of about 25 feet. The moisture was reduced to 12% on cockled, second-sheet writing paper running 250 feet per minute by this arrangement.

In making a demonstration on a Yankee drier running paper toweling, the burner was placed over the wire about 6 feet from the drier. Thermometers were placed on the under side of the wire about 12 inches after the burner. There was no rise in the temperature of the wire but the temperature of the paper increased about 27°F.

On heavy paper that has a higher moisture content, more burners can be used which will raise paper temperatures but still to not over 212°F. The number of burners that can be safely used depends entirely upon the amount of moisture to be removed and the speed at which the paper is to be run over the burners.

When using equipment with a surface temperature of 2600°F. for drying coated paper, the first reaction with most engineers is that case hardening will take place. Actually, this does not happen. Here again the evaporation retains a safe temperature in the paper. When paper passes over a heated steam drier, it is pressed on a hot surface which has a tendency to seal over the paper surface. This continuous contact with hot driers will case-harden paper on both sides and will retard moisture exaporation. Paper run over steam driers has to be heated through its entire thickness before evaporation can take place on the free side. There is an insulating barrier, which is the paper itself, between the hot drier and the exposed surface where moisture can be released. This form of drying has a tendency to defeat its own purpose to a certain extent. With radiant burners the moisture has a chance to evaporate from free paper surfaces.

Gummed paper has been run under a radiant burner and there is an installation now operating where this material is traveling on a conveyor under inverted burners which has doubled the drying speed without

scroching. Tests show that, when applying heat to the back or free side of gummed paper, the burner control is not quite so critical and there is less chance of scorching or blistering.

Picking on the first one, two, or three driers can, it is believed, be reduced if not eliminated entirely by the use of radiant burners. In a recent test with one burner there was an indication of reduced picking but, due to the high speed of the machine and insufficient heat from one burner, it was not conclusively proved that picking could be eliminated. However, the author believes that picking can be reduced or eliminated if enough heat is applied a short distance from the first drier. This thinking is supported by some paper mill engineers.

The fusing of organisol, surface coatings, and resin curing, has been successfully accomplished with radiant burners without expensive ovens by applying the burner in such a manner that the material is first run under the burner using the radiant heat and then is run into an enclosure utilizing the escaping hot products of combustion. The length of enclosure depends upon the speed at which the material is to run.

The cockling of light papers can be successfully accomplished with a radiant burner. However, all paper tension must be eliminated after the paper has passed over the burners.

The drying of felts is an ideal installation for radiant burners. Of course, care should be taken that there is sufficient moisture content in the felt and the speed of the machine is fast enough that, when the felt is run over the burners, the high temperature will not damage it. Usually, two or three burners can be installed on a felt without danger of overheating on the average machine.

To accelerate drying on existing machines, available space must be considered. Radiant gas burners can be installed on most paper driers below or above the paper without making changes to the machine. Burners have been installed on the bottom of the first drier in the drying section, this location being ideal from the standpoint of efficiency. They may be installed between the press rolls and drier section, either above or below the paper, or both. The distance between the surface of the paper and burner should be from 3 to 6 inches, depending upon speed of paper and moisture content. In making a radiant burner installation the physical characteristics of the machine on which the installation is to be made must be taken into consideration, and the equipment installed so as not to interfere with operation. There is very little difference in efficiency whether the burners are installed under the paper or above in an inverted position when paper is run past them in the open.

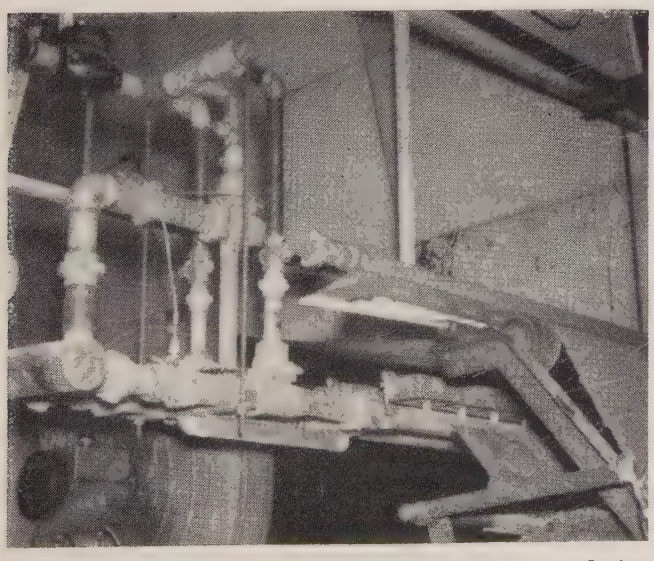

Fig. 2. Application on roofing felt before it enters drying range

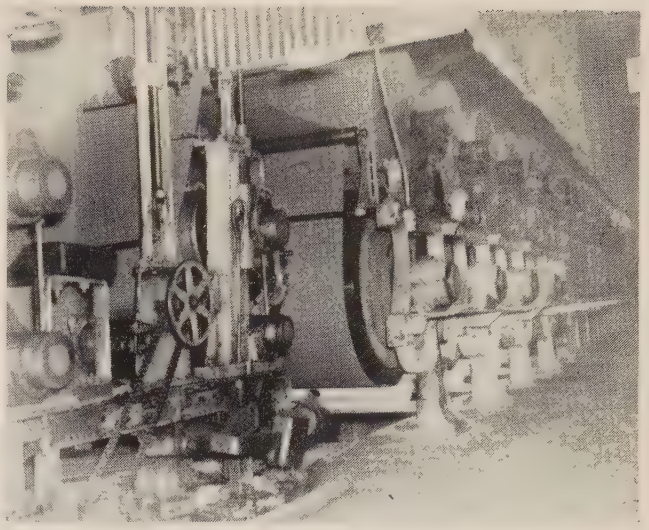

Fig. 3. Installation beneath the first four driers

The safe operation of radiant burner installations depends largely upon controls used. Air from a blower is delivered to a flowmixer which inspirates gas from the gas line, and from this point an air and gas mix is delivered to the burner manifold. The shut-off valves are installed in the gas line and, in the event paper should stop over the burner, the gas shuts off but not the air. With the air allowed to continue to blow on the refractory the burners are cooled rapidly Safety gas shutoffs are installed in the gas line and are connected to centrifugal plugging switches, tension switches, or a photoelectric switch whichever is desired. These switches are installed to shut off burners in the event of machine stoppage or paper breakage. Control relays are tied into the drive circuit of the machine and are also connected with safety shut-off valves. If the air supply to the flowmixer should fail, thereby ceasing to inspirate gas, the zero governor in the gas line will automatically shut off. However, this cannot be considered as a safety shutoff, and a pressure switch is installed on the air line connected to the safety shut-off valve. Where burners are used to furnish heat to an enclosure, combustion safeguards are used. This equipment is designed to shut off main gas supply if combustion should fail for any reason. Time-delay relays are employed so that the purging fans or exhaust fans must be started or run for a period of time before the burners can be ignited. Air flow switches are also provided to insure operation of the exhaust system.

From a standpoint of safety, it might be well to point out at this time that, on a recent test with paper running over a burner installed in the open, a highly inflammable photographic film was embedded

in the paper. This film did not ignite. While this does not prove that such material could not be ignited, it does show that it did not ignite under these high temperatures at the speed involved.

EVAPORATION RATES AND COSTS

It has been found that with heat applied to paper through the medium of a radiant burner, 7000 B.t.u. will evaporate 2 to $2^1/_2$ pounds of water. For example, a burner that has an output of 7000 B.t.u. per hour per inch and is 100 inches long will evaporate 200 to 250 pounds of water per hour. These figures are based upon averages. While a good rule-of-thumb figure is the 2-pound rate, the results are very often better. The success of a radiant burner installation depends upon how it has been installed. Care should be taken in making the installation that all possible heat generated, either radiant heat or heated air, is used.

Actual tests on paper-making machines have shown that one radiant burner is equivalent to three or three and one-half driers. These figures are also conservative.

The fuel consumption of a radiant burner operating at full capacity is as follows:

1000 B.t.u. natural gas—7 cubic feet per inch of burner per hour.
530 B.t.u. city or manufactured gas—14 cubic feet per inch of burner per hour.
21,500 B.t.u. per pound propane or butane—$^1/_8$ pound per inch per hour.
128,000 B.t.u. per gallon No. 1 oil or kerosene vaporized about $^1/_2$ gallon per foot of burner per hour.

The output of a radiant burner when vaporized oil is used is about 5000 B.t.u. per inch as compared to about 7000 B.t.u. per inch when using any of the other gases including propane and butane.

Gas cost as compared to steam cost is difficult to compare. It has been quite hard to get steam cost per pound of paper dried. Most engineers figuring the same job will come up with different answers but, if everything in steam generation, distribution, and drier efficiency is taken into account, gas-fired radiant burners in many cases come pretty close to equalling, if not bettering, steam cost as to pounds of paper dried.

Source of heat	*Rate per 1000 cu. ft. of gas, dollars*	*Cost per 700–800 lb. water evaporated (at 50% efficiency), dollars*
Manufactured gas (approximately 535 B.t.u. per cu. ft.)	0.40	1.65
	0.50	2.05
	0.60	2.45
	0.70	2.86
	0.80	3.29
Natural gas (approximately 1050 B.t.u. per cu. ft.)	0.12	0.25
	0.15	0.313
	0.20	0.418
	0.30	0.61
	0.50	1.04
	0.75	1.37
	1.00	2.10
	Rate per pound, dollars	
Butane or propane gas (approximately 21,500 B.t.u. per lb.)	0.0125	1.27
	0.015	1.53
	0.02	2.03
	0.04	4.08
	0.06	6.11
	0.08	9.16
	Rate per kw., dollars	
Electricity (3414 B.t.u. per kw.)	0.005	3.21
	0.01	6.43
	0.015	9.65

It is interesting to compare the cost of drying with radiant gas burners with that of drying with infrared lamps. With radiant burners the heat is emitted from a relatively large refractory area. In the case of lamps the heat is emitted from a very small glowing filament. Both show about the same energy but the total heat differs greatly. The evaporation of water requires a definite amount of heat regardless of heat source, whether the heat units are generated from gas, steam, or electrictiy. As an example, four 70-inch radiant burners would have a capacity of 1,960,000 B.t.u. This is the heat equivalent of 574 kilowatts and would, under average conditions, evaporate in excess of 560 pounds of water per hour. With a gas rate of 0.15 a therm, the cost to evaporate 560 pounds of water would be $2.85. With electricity at $1^1/_2$ cents per kilowatt, the same water evaporation would cost $8.61. These fuel rates are average rates in the New England territory.

Then consider the space required. If 250-watt lamps were used, it would take 2296 lamps, or 1148 500 watt lamps. The space requirements alone would in most cases make an infrared lamp installation impractical. As to maintenance, in radiant burners the only expendible material is the refractory which may have to be replaced every year if in constant use.

The subject of induction heat for a source of drying may be considered. In this type of heating, electricity is used to generate heat and, in all water evaporation applications, large amounts are required; therefore the fuel cost of operation of this type of equipment parallels the fuel cost of infrared lamps. Care should be taken when selecting accelerating drying equipment as to what the heat source is. There is a possibility of misapplication of induction heating if all facts are not weighed.

Cost of equipment is quite important. An induction heating unit having a capacity of only a few kilowatts will cost from $25,000 to $35,000 for complete installation. Infrared lamp installations run somewhat less, whereas a radiant burner installation averages $1800 to $4000 depending upon width of paper and number of burners desired. Two 70-inch burner installations will run about $1800 complete with all controls and will increase drying speed about 8% on a machine with 56 driers operating on 36- to 42-pound steam. These are average figures.

It will be noted that radiant burners have been considered mostly as a method of accelerating drying and installed at the wet end of the machine. However, it is possible to utilize radiant heat to do the complete drying. In some textile applications, the engineering and heat use have been worked out so that radiant gas burners are doing the complete job. At some future date, a complete paper drier will probably be designed using radiant burners for heat energy by applying the heat directly on the paper. These driers will use less space with higher drying speed at less fuel cost due to efficiency of heat applied directly to paper instead of heating drums or some other means of heat transmission.

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Detection and Control of Tester Error

J. G. STRIEBY

Check testing systems can aid those engaged in routine testing operations to assure control of tester bias and precision. Three specific examples of such systems which have been found useful in connection with variables testing methods are presented here.

Supervisors of routine testing and inspection operations continuously face the problem of assuring reliable results. The supervisor must know when to adjust testing apparatus, when to check testing procedures, when to intensify training of personnel, how to discover and correct honest and dishonest tester biases, and how to convince operators and management that such actions are effective. The results of routine testing and inspection are of little value unless the people for whom the work is done have sufficient confidence in the validity of the results to use them as bases for action on process or product. The routine tester or inspector needs self-confidence and means for demonstrating that the confidence is justified.

Experienced supervisors of routine testing work develop good intuitive judgment regarding validity of results. Often they operate routine systems for checking the work of testers. If systems for checking testers are operated reasonably and fairly, they have beneficial technical and psychological effects which go far toward accomplishing the desired ends. If the systems depend largely on subjective judgment for interpretation and decision as to when to act on the testing process, their efficiency and fairness may be open to serious question.

The theory of errors and modern sampling theory provide concepts and methods for designing and operating objective systems for detection and control of tester errors. Systems designed on that basis provide improved aid to supervisory judgment and can be arranged to provide whatever degree of assurance is required. Every installation of an objective system which the writer has observed has aided in detecting irregularities not previously known to exist. No system for control of or inspection for quality should be considered complete until it provides for systematic check on the work of testers or inspectors.

Precision (reproducibility), accuracy (absence of bias), theory of measurements, sampling theory, theory of errors, and related topics are discussed in a mass of literature. References listed at the end of this paper are examples. The discussion below is limited to specific examples of systems which have been found useful. Sufficient detail is supplied to show methods of computation and operation but no attempt is made to treat the broad theoretical aspects.

EXAMPLES OF APPLICATION PRINCIPLES

The data presented below have been modified but in such a manner that the principles are not obscured.

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Example 1.—Total Ash Test

A system for process control of total ash content of book paper requires that a single ash test be made every time a reel of paper leaves the machine. The test is made by the usual procedure of ignition in a muffle furnace. The test specimen is cut from a larger specimen of paper other portions of which are used for other tests. To operate the check testing system, it is required that the tester cut two ash test specimens adjacent to each other from the larger specimen. One portion he tests, the other he identifies with reel and run numbers and places in a closed container. Once each day the supervisor collects these specimens which he then takes to the laboratory where check tests are made on some of them selected at random. The laboratory test value is compared with the value previously recorded in the testing station. If the difference between the two test values is larger than can reasonably be accounted for on the basis of chance error, that is usual testing precision and material variation, the cause of the difference is sought. At first each tester's work was checked daily for one specimen. Later, after improved furnace temperature control, uniform technique, and more careful arithmetic had overcome irregularities, the frequency was reduced to two check tests per tester per week.

Figure 1 shows the nature of the chart of check test results which is maintained in the testing station. One such chart is posted for each tester involved. The charts are kept strictly up to date and supervisors and testers can tell at a glance just how well the testing process is controlled. As long as difference values are distributed in random manner about the central line (difference = 0.0) and within the dotted limits, confidence in the testing system is justified. One difference value outside the limits or any other evidence of nonrandom distribution gives the signal to investigate the testing process. After investigation is completed, daily check tests are made for a week or longer to regain assurance of satisfactory testing.

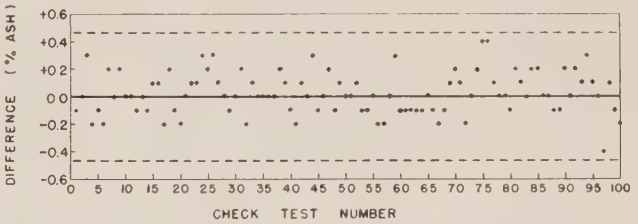

Fig. 1. Total ash test. Tester value minus laboratory value

To illustrate the methods of computation portions of the data plotted in Fig. 1 are reproduced in Table I. Column (I) shows the results of the tester's ash deter-

Table I

Check test No.	% Ash tester (I)	% Ash lab. (II)	Diff. (III)	(Diff.)² (IV)
1	25.7	25.8	−0.1	0.01
2	28.3	28.3	0.0	0.00
3	23.4	23.1	+0.3	0.09
4	27.7	27.9	−0.2	0.04
5	27.7	27.8	−0.1	0.01
..	....	....	...	....
..	....	....	...	....
25	29.4	29.2	+0.2	0.04
26	25.2	24.9	+0.3	0.09
27	25.0	24.9	+0.1	0.01
28	27.7	27.7	0.0	0.00
29	22.3	22.4	−0.1	0.01
..	....	....	...	....
..	....	....	...	....
56	26.7	26.9	−0.2	0.04
57	21.5	21.7	−0.2	0.04
58	29.7	29.7	0.0	0.00
59	23.8	23.5	+0.3	0.09
60	27.0	27.1	−0.1	0.01
..	....	....	...	....
..	....	....	...	....
75	29.9	29.5	+0.4	0.16
76	21.9	21.5	+0.4	0.16
77	28.0	27.9	+0.1	0.01
78	23.7	23.7	0.0	0.00
79	21.5	21.5	0.0	0.00
..	....	....	...	....
..	....	....	...	....
96	25.3	25.3	0.0	0.00
97	29.5	29.9	−0.4	0.16
98	22.5	22.4	+0.1	0.01
99	27.1	27.2	−0.1	0.01
100	21.4	21.6	−0.2	0.04
		Sum	+2.3	2.41

minations, column (II) shows the laboratory results, column (III) shows the difference, tester per cent ash minus laboratory per cent ash, and column (IV) shows the square of the difference. The sums of columns (III) and (IV) are for the 100 check tests and not just those values tabulated here.

Preliminary work indicated that one was justified in assuming that the difference values should be normally distributed with a mean of 0.0 and standard deviation of about 0.15% ash when testing is proceeding satisfactorily. For the $n = 100$ check test values the standard deviation is

$$\frac{1}{n}\sqrt{n\,[\text{sum of (diff.)}^2] - (\text{sum of diff.})^2} = \frac{1}{100}\sqrt{100\,(2.41) - (2.3)^2} = 0.1535$$

and the mean difference is

$$\frac{\text{sum of diff.}}{n} = +\,2.3/100 = +\,0.023$$

Populations with mean of 0.0 and standard deviation of 0.15 frequently will produce samples of $n = 100$ with means and standard deviations comparable to the values observed here. The central line is, therefore, set at diff. = 0.0 and the dotted limits at $0.0 \pm 3(0.15)$.

The results of each tester should be reviewed frequently to see that the mean of 0.0 is being maintained and that the standard deviation is remaining essentially constant.

In operation this system is about as simple as can be and it has worked well in several applications. It is, however, open to some serious objections. The mathematical model (i.e., normal distribution of testing error and material variation) is more simple than the parts of the physical world often dealt with. Verification of the model is laborious. If serious trouble exists when the system is being setup, the difference values are not in statistical control, and the degree of uncertainty with which parameter values are estimated by sample values cannot be stated rigorously. Variations in either material or testing can cause values to fall outside limits and reasons for the trouble are not readily apparent. If the several testers involved differ in ability to test precisely, the difference is not detected directly by the system but by laborious special data processing. The use of single test values limits the sensitivity of the system.

When it is possible to make check tests on identical specimens, that is where tests are not destructive or the specimens can be made homogeneous, for example solutions, slush pulp, etc., a system similar to that of example 2 is preferable.

Example 2.—Coating Consistency

Process control of total solids content of paper coating color requires that a tester take specimens from each batch and make a total solids determination on each specimen. The specimens when removed from the batch are about 1 pint in volume. A very small portion of each specimen is used for the single test which is made according to a rapid drying, gravimetric procedure. The remainder of each specimen is placed in a separate, sealed container, properly marked with test result, batch number, and tester's initials. Daily all the specimens are taken to the laboratory where some are selected at random for check testing. The laboratory makes duplicate tests on each specimen selected using a conventional, slow drying, gravimetric method. The specimens so selected and tested are then returned to the tester with no identification except tester's initials and a laboratory code number. The indicated tester then makes a test on the returned specimen. Thus, two tests by the tester and two by the laboratory are available for each specimen involved in the check testing system.

The average of the two single laboratory tests on each specimen is compared with the average of the two single testers tests on the same specimen. If the difference is larger than can be attributed reasonably to chance testing variation, investigation is started immediately, and the frequency of check testing is increased to give quick assurance that trouble has been eliminated.

The difference between the two laboratory tests and the difference between the two tester tests provide both a measure of and a means for controlling testing precision.

Figure 2 shows the nature of the chart posted at the testing station. One such chart is posted for each tester and the charts are kept up to date so that the tester, his supervisor, and interested operators can be kept informed currently about the degree of testing control.

The chart is in two parts. The upper part shows the difference between the tester's results and those of the laboratory. As long as the difference values are distributed in random manner about the central line (difference = 0.0) and inside the dotted limits, it is

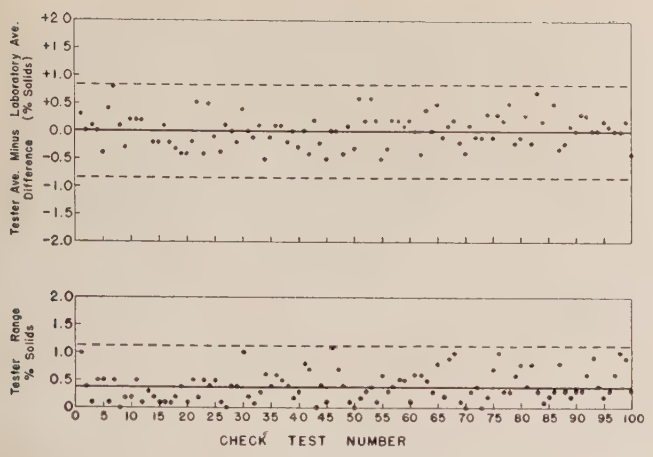

Fig. 2. Coating consistency

concluded that the testing process is proceeding satisfactorily. One value outside the limits or any other evidence of nonrandom distribution is the signal that irregularities should be sought and corrected.

The lower part of the chart shows the range, that is the difference between the two tests by the tester on each specimen. A range value outside the upper limit of this chart indicates that the precision of the testing process as carried out by the tester has changed and is the signal to investigate equipment and procedure in the testing station. A similar chart of laboratory range is maintained in the laboratory and used similarly to control the precision of the laboratory technique.

Table II contains portions of the data plotted in Fig. 2 and is submitted to illustrate methods of computation. Column (I) shows the average of two single tests by the tester; column (III) the average of the two single tests made by the laboratory on the same specimen. Column (V) shows the difference between the two averages. Column (II) shows the tester's range, i.e., difference between two single tests on one specimen and column (IV) shows the laboratory's range. The values are in per cent total solids and the totals shown are for all 100 check tests and not just those shown in the abridged table.

Table II

Check test No.	*Average tester,* n = 2	*Range tester,* n = 2	*Average lab.,* n = 2	*Range lab.,* n = 2	*Diff.*
1	55.6	1.0	55.3	0.2	+0.3
2	40.8	0.4	40.8	0.5	0.0
3	59.9	0.1	59.8	0.0	+0.1
4	57.9	0.5	57.9	0.4	0.0
5	58.5	0.5	58.9	0.0	−0.4
..	....	...	....	...	...
..	....	...	....	...	...
26	42.2	0.1	42.6	0.5	−0.4
27	50.0	0.0	49.9	0.2	+0.1
28	47.2	0.4	47.2	0.4	0.0
29	42.3	0.4	42.5	0.0	−0.2
30	48.9	1.0	48.5	0.3	+0.4
..	....	...	....	...	...
..	....	...	....	...	...
56	59.2	0.3	59.5	0.4	−0.3
57	40.6	0.4	40.4	0.5	+0.2
58	48.8	0.5	48.6	0.1	+0.2
59	44.2	0.5	44.1	0.2	+0.1
60	40.3	0.1	40.1	0.1	+0.2
..	....	...	....	...	...
..	....	...	....	...	...
76	49.6	1.0	49.3	0.0	+0.3
77	52.9	0.3	52.7	0.3	+0.2
78	41.1	0.3	40.6	0.0	+0.5
79	53.3	0.6	53.5	0.1	−0.2
80	55.6	0.8	55.7	0.3	−0.1
..	....	...	....	...	...
..	....	...	....	...	...
96	43.2	0.3	43.1	0.2	+0.1
97	42.5	0.6	42.5	0.5	0.0
98	57.2	1.0	57.2	0.1	0.0
99	42.4	0.9	42.2	0.2	+0.2
100	57.4	0.3	57.8	0.2	−0.4
	Sum	39.6		22.4	+1.1

The average range observed for the tester is 39.6/100 = 0.396 and that for the laboratory is 22.4/100 = 0.224. Converting these values to standard deviation, $\sigma_T = 0.396/1.128 = 0.351$ and $\sigma_L = 0.224/1.128 = 0.199$ (see reference *17*, page 205), an estimate is had of the testing precision in units of per cent total solids. It can be shown that the two estimates differ too much to be due to chance sampling fluctuations (one method is given in reference *17*, page 127). Study of the situation indicates that the difference is a reasonable one and due to the fact that the tester's procedure is a rapid one and essentially less precise than that used in the laboratory. Similar differences observed between testers all presumably using the same equipment and procedure should be cause for alarm. Some such differences have been observed. Careless procedure has been found to be the common cause but some cases of dishonesty have been observed.

The range charts are arranged in conventional manner. The solid line is placed at the average range value (i.e., 0.396 for the tester and 0.224 for the laboratory). The limits are 0.396 (0) to 0.396 (3.268) or 0.0 to 1.29 for the tester chart of Fig. 2 and 0.224 (0) to 0.224 (3.268) or 0.0 to 0.732 for the laboratory chart which is not shown. For details of the method see reference *17*, page 204.

The average difference between laboratory and tester tests is +1.1/100 = +0.011. It can be shown that differences of this magnitude can occur by chance so frequently when the true difference is *nil* that it is reasonable to conclude that no bias exists between tester and laboratory. This is an important point. In this case the results for the various testers and the laboratory should show no bias if good practices prevail. There are cases, however, where check tests are not made by the same procedure as the original test and real bias may be expected. In such cases the several testers should not differ significantly in the amount of bias and if the bias is tolerable, the central line of the difference chart should be placed not at 0.0 but at a value equal to the best estimate of the bias.

The difference chart of Fig. 2 has the central line at 0.0 and limits which are three times the standard deviation of the difference above and below the central line. The standard deviation of the difference may be estimated readily from the σ_T and σ_L values which were estimated above from the average range values as follows

$$\sigma \text{ diff.} = \sqrt{\frac{\sigma_T^2}{2} + \frac{\sigma_L^2}{2}} = \sqrt{\frac{(0.351)^2 + (0.199)^2}{2}} = 0.285$$

The chart limits are, then, 0.0 ± 3 (0.285) or −0.855 to +0.855.

One difference value, that for check test number 13, is outside the chart limits. Careful investigation failed to reveal any reason and subsequent check tests are satisfactory. It seems reasonable to believe that this value is one of those rarely expected chance cases.

The mathematical model used in this example (normal distribution of difference values) is more likely to correspond to the physical world than that of example 1. Averages tend to be distributed normally and variation in material is practically excluded from consideration. Bias or accuracy is considered separately from precision or reproducibility. Either may be in or out of control regardless of the other. Reasons for trouble are more easily found. The comparison of averages rather than single values increases the sensitivity of the system. In fact, operating characteristics curves may be prepared to evaluate the sensitivity quantitatively. The example uses duplicate tests but still greater sensitivity can be obtained, if desired, by making the tests in triplicate, quadruplicate, etc.

The system used in this example has been successful in a variety of cases. There are cases where the simple sampling formulas do not fit the conditions and more elegant statistical techniques are required. One such case is discussed in Example 3.

Example 3.—Bleached Pulp Brightness

A system for process control of brightness of bleached pulp requires that the tester periodically take specimens of the slush pulp from a point just after the washer. Each specimen is mixed carefully and divided into two portions. One portion is placed in a clean, closed container and set aside to be picked up by the laboratory for possible check test. From the other portion the tester prepares three handsheets according to standardized procedure. A tab is prepared from each sheet and on each sheet six brightness readings are made on the General Electric Reflectance Meter.

The laboratory collects the containers daily and selects at random the specimens for check test. The laboratory uses procedure and equipment similar to that used by the tester. The same reflectance meter is used by both tester and laboratory and is kept in calibration by procedure not considered here.

Both parties report the average of the 18 brightness readings, the range of the six readings for each of the three sheets and the range of the three sheet averages. The two averages are compared for control of accuracy. The values of range of the six readings on each sheet provide a measure of and a means for controlling variation within sheets. The range of the three sheet averages provides a measure of and a means for controlling variation between sheets. Taken together these range values provide a measure of and a means for controlling precision.

The use of both range values for measuring and controlling precision and setting limits for accuracy is necessary because sampling in this case is not random but is stratified. Analysis of variance of the data demonstrates clearly that there is a significant component of variation from sheet to sheet in addition to the component of variation within the sheets. Pooling the two components as though sampling were random provides poor means for control of precision and, in addition, results in accuracy limits that are too narrow to be realistic. That is, control of precision in such cases requires control of both within and between sheet variation. Also, the use of variance, standard deviation or range of the 18 readings as though they were random is a model which does not correspond to actual conditions. To properly fit conditions for accuracy limits the two components of variation must be estimated separately and then combined with proper weighting.

Figure 3 shows the type of chart maintained at the tester's work station. A chart of the laboratory range between the three sheet averages is maintained in the laboratory. The use of the charts is similar to that discussed under example 2. Charts for the range between values within single sheets may be maintained, if desired. In this case the variation has seemed to be well controlled. The values are watched for irregularities and compared with control chart limits but charts are not maintained.

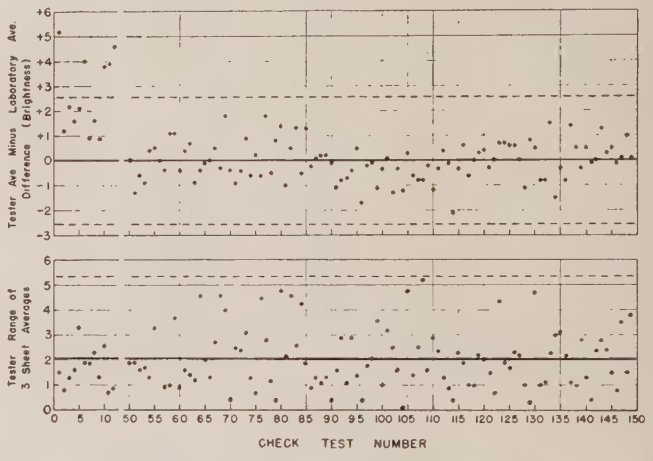

Fig. 3. Bleached pulp brightness

The first data shown in Fig. 3 and Table III illustrate a condition existing when check testing was started. The laboratory results were consistently lower than those of the testers. Any of several objective techniques indicate that the difference is too large to be due to chance variations in testing. The data from check test number 50 on illustrate the nature of the data after the condition was corrected.

Table III shows portions of the check test data to illustrate methods of computation and recording. Only those data from check test number 50 on are considered in what follows. The sums shown are for check tests 50 to 149, inclusive, and not just for the values shown in the abridged table. Columns (I), (II), and (III) show the range values for tester's results within individual sheets. Columns (VI), (VII), and (VIII) show the laboratory range values similarly. Columns (IV) and (IX) show the range of the three sheet averages for tester and laboratory, respectively. Column (V) shows the average of the tester's 18 individual brightness values and column (X) the same data for the laboratory. Column (XI) shows the difference between the two averages, i.e., tester average minus laboratory average.

Limits for the range charts are computed by the same conventional method as under example 2 (reference *17*, page 204) as follows

A. Range chart for tester within sheet variation
   central line = 1462.8/300 = 4.876
   limits are 4.876 (0) to 4.876 (2.004) or 0 to 9.77
B. Range chart for laboratory within sheet variation
   central line = 889.5/300 = 2.965
   limits are 2.965 (0) to 2,965 (2.004) or 0 to 5.94
C. Range chart for tester between sheet variation
   central line = 207.7/100 = 2.077
   limits are 2.077 (0) to 2.077 (2.574) or 0 to 5.35
D. Range chart for laboratory between sheet variation
   central line = 142.2/100 = 1.422
   limits are 1.422 (0) to 1.422 (2.574) or 0 to 3.66

Testing precision is clearly superior in the laboratory to that in the testing station. The reason is not yet apparent but since all testers appear to be in good agreement and in good control in this regard, it seems certain that it is connected with some matter of technique or equipment not now recognized as important. The check testing system is not disturbed by this difference in precision as long as the precisions remain controlled.

To arrive at limits for the difference chart it is first necessary to estimate the variances within and between sheets for both tester and laboratory. Analysis of variance techniques accomplish the estimation readily but, where such large quantities of data are available as in check testing systems, the range values may be used satisfactorily as follows (*20*):

For the tester:
Variance within sheet = $(4.876/2.534)^2 = 3.70$
$\frac{\text{Variance within sheet}}{6}$ + variance between sheet = $(2.077/1.693)^2 = 1.51$
Variance between sheet = 1.51 −3.70/6 = 0.89
Variance of the mean of the 18 test readings = 3.70/18 + 0.89/3 = 0.502

For the laboratory:
Variance within sheet = $(2.965/2.534)^2 = 1.37$
$\frac{\text{Variance within sheet}}{6}$ + variance between sheet = $(1.422/1.693)^2 = 0.706$
Variance between sheet = 0.706 −1.37/6 = 0.478
Variance of the mean of the 18 test readings = 1.37/18 + 0.478/3 = 0.236

Table III. Bleached Pulp Brightness

	Tester					Laboratory					
	Range of readings on each sheet			Range of three sheet averages	Average of all readings	Range of readings on each sheet			Range of three sheet averages	Average of all readings	Diff. between the two averages
Check test No.	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
1	6.6	4.8	6.9	1.5	81.5	3.4	4.1	4.2	2.5	76.4	+5.1
2	1.6	4.6	2.0	0.8	80.3	4.8	3.3	3.2	0.1	79.1	+1.2
2	5.1	4.9	3.1	1.3	76.3	2.5	2.0	3.2	1.6	74.1	+2.2
4	4.8	5.3	4.2	1.6	74.4	1.6	2.0	2.0	1.0	72.8	+1.6
5	1.9	3.9	3.8	3.3	77.1	2.3	2.1	2.1	1.8	75.0	+2.1
6	2.3	2.6	6.3	1.9	80.8	3.3	5.2	4.0	1.1	76.8	+4.0
7	6.4	5.1	5.5	1.9	74.4	3.4	2.9	3.2	1.0	73.5	+0.9
8	5.7	3.9	3.5	2.3	77.0	3.4	3.1	2.0	1.1	74.5	+1.6
9	3.1	3.6	4.3	1.3	76.3	1.7	2.2	3.2	1.6	75.4	+0.9
10	6.8	5.5	2.8	2.6	78.3	2.3	1.6	2.2	1.0	74.5	+3.8
11	3.8	7.0	6.7	0.7	79.6	1.9	4.8	3.5	1.5	75.7	+3.9
12	4.5	6.5	7.5	0.9	81.0	4.8	3.7	4.1	1.8	75.4	+4.6
13	6.6	5.3	6.5	3.3	75.7	1.8	2.9	2.3	0.2	74.4	+1.3
14	5.6	5.2	5.0	3.9	79.3	1.9	2.7	2.7	1.5	74.4	+4.4
15	5.6	7.3	8.1	1.6	79.8	4.3	3.0	3.4	2.2	73.9	+5.9
16	5.0	3.6	3.5	1.9	80.4	2.6	2.4	2.0	1.8	79.8	+0.6
..	...	...	...	...	....	...	...	...	...	....	.....
..	...	...	...	...	....	...	...	...	...	....	.....
50	4.9	5.4	4.2	1.9	79.8	3.7	1.8	3.5	1.7	79.8	0.0
51	6.1	6.5	5.3	1.9	78.5	3.1	3.8	3.2	0.7	79.8	−1.3
52	5.2	5.4	4.2	1.6	77.2	3.0	3.6	1.5	1.4	77.8	−0.6
53	3.8	1.8	7.8	1.7	78.8	3.5	2.6	2.3	1.3	79.7	−0.9
54	7.5	4.8	3.4	1.3	79.6	2.3	3.8	3.2	2.6	79.2	+0.4
..	...	...	...	...	....	...	...	...	...	....	.....
..	...	...	...	...	....	...	...	...	...	....	.....
75	3.1	8.0	5.0	0.7	78.6	2.7	3.1	3.6	0.3	78.4	+0.2
76	3.9	0.7	4.8	4.5	79.1	1.8	1.8	2.9	1.0	79.7	−0.6
77	3.7	3.6	4.3	2.8	77.1	2.5	3.4	3.2	0.6	75.3	+1.8
78	3.8	4.0	3.7	1.2	79.6	2.6	2.2	2.6	1.3	80.1	−0.5
79	4.1	4.6	7.4	0.4	78.3	2.5	3.4	2.5	1.7	77.5	+0.8
..	...	...	...	...	....	...	...	...	...	....	.....
..	...	...	...	...	....	...	...	...	...	....	.....
100	2.8	4.4	4.2	1.0	79.5	4.2	3.9	3.6	1.6	79.8	−0.3
101	4.3	5.5	3.0	3.2	77.2	2.7	1.5	4.4	1.6	77.1	+0.1
102	3.5	4.9	4.4	2.5	79.9	2.2	1.5	2.3	1.7	81.2	−1.3
103	3.4	5.0	5.6	1.6	78.7	4.2	4.1	4.6	1.1	79.0	−0.3
104	2.3	5.7	4.3	0.1	79.7	3.3	3.2	3.3	1.3	80.9	−1.2
...	...	...	...	...	....	...	...	...	...	....	.....
...	...	...	...	...	....	...	...	...	...	....	.....
125	5.4	2.8	3.3	1.7	79.9	4.1	3.8	3.7	3.4	79.3	+0.6
126	2.5	1.6	8.4	2.3	77.1	2.9	4.6	3.3	0.3	76.5	+0.6
127	4.5	4.0	4.6	2.2	77.0	1.6	4.2	2.0	2.1	77.0	0.0
128	5.1	6.4	4.6	1.0	79.8	3.5	3.1	1.9	1.4	80.9	−1.1
129	5.9	4.5	7.9	0.3	78.9	4.5	4.4	2.6	0.7	78.1	+0.8
...	...	...	...	...	....	...	...	...	...	....	.....
...	...	...	...	...	....	...	...	...	...	....	.....
145	5.5	5.8	4.4	1.5	79.1	3.1	2.3	3.7	1.5	78.6	+0.5
146	3.0	7.0	7.7	0.8	77.9	2.4	3.7	3.1	1.5	78.0	−0.1
147	2.6	4.1	3.3	3.5	77.5	2.5	4.6	3.5	2.4	77.3	+0.1
148	3.7	3.7	4.3	1.5	79.7	2.6	2.5	2.5	0.9	78.7	+1.0
149	3.1	5.6	6.5	3.8	78.2	3.8	2.6	2.2	2.2	78.1	+0.1
Sum		1462.8		207.7			889.5		142.2		−3.9

Chart limits are based on the standard deviation of the difference between the two averages of 18 values each which is calculated as standard deviation of difference $= \sqrt{0.502 + 0.236} = 0.859$ and the limits are central line ± 3 (0.859). In this case the average difference is $-3.9/100 = -0.039$ and it can be shown that average differences this large occur frequently when the true difference is *nil*. The central line, then, is placed at 0.0 and the limits at -3 (0.859) and $+3$ (0.859) or -2.57 to $+2.57$.

CHECK TESTING SYSTEMS IN GENERAL

The best check testing system for any given case can be set up only in the light of full knowledge of technical, economic, and statistical conditions and requirements prevailing. The three systems discussed here and their modifications are only a few of the many possibilities. Some may be quite elegant (*21*).

The discussion here has been confined to testing systems which measure on a variables scale. Where attributes examinations are made, for example, fraction defective with respect to holes, spots, wrinkles, dirt, cuts, poor packing, etc., control of the reproducibility and accuracy of the results are likely to be still more important. Design, installation, and operation of attributes check systems may be more difficult than those for variables, but the statistical methods are likely to be more simple and are obvious to those familiar with the theories of attributes distributions.

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Zinc Hydrosulphite Treatment of Groundwood

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Brightening of groundwood by zinc hydrosulphite is a Pacific Coast development used mainly in connection with the manufacture of newsprint. A hot process developed by the technical staff of the Powell River Company Limited is the one in general use. The hot process employs zinc hydrosulphite for a treatment period that is governed by the temperature and amount of treatment. The pulp is washed following its retention to control the period and to obviate subsequent corrosion. A unique high capacity groundwood washer is described. The procedures for treatment of groundwood for newsprint and that for papers requiring a greater brightness is outlined. Values of brightness improvement are given for various treatment rates and temperatures, of groundwood from various Pacific Coast woods. The method of manufacture of zinc hydrosulphite is outlined.

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The brightening of groundwood by means of zinc hydrosulphite (ZnS_2O_4) is a Pacific Coast development. It was brought about in connection with the manufacture of newsprint by reason of the fact that groundwood from western hemlock and balsam fir, the species predominantly used, has a reddish color and the brightness is not as good as that from Sitka spruce, the other main species.

Prior to the introduction of zinc hydrosulphite, alum was commonly used to improve the inherent color deficiencies and also to alleviate process discoloration, but the effects were far from satisfactory.

As far as is known, hydrosulphites were first introduced in commercial application for the brightening of newsprint by Dr. Hirskhind of the Great-Western Electro Chemical Company by what may be termed

a normal temperature process wherein the hydrosulphite was added to the mixed stock immediately ahead of the paper machine. However, corrosion was excessive and a greater color improvement was desired, therefore, a hot process was developed by the technical staff of the Powell River Co., Powell River, B. C., which is the one now in general use on the Pacific Coast.

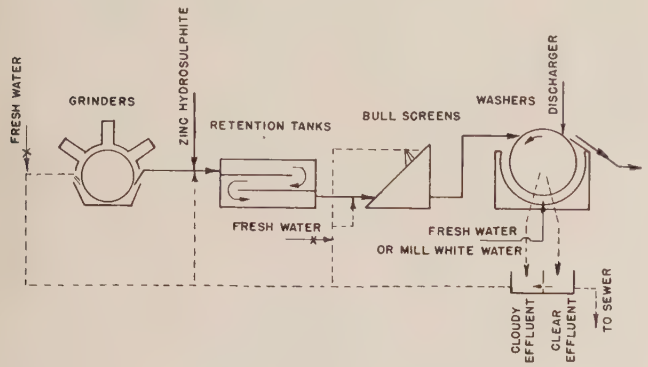

Fig. 1. Brightening at grinder pits

The hot process employs only zinc hydrosulphite at elevated temperatures up to a maximum of about 200°F. The stock is washed after the treatment and may stand without color setback before being used. While the main utilization of this process has been the brightening of Pacific Coast groundwood for newsprint wherein a brightness increase in the order of 4 to 5 points GE is all that is required, it also has application to the manufacture of higher grade groundwood papers as brightness improvement to 10 to 13 points GE on pulps from West Coast woods is feasible.

DESCRIPTION OF PROCESS

While at normal temperatures, 70 to 80°F., hydrosulphites are found to produce an appreciable brightening effect, considerable time is taken in exhausting the chemical to bring about a maximum result. At elevated temperatures with a hydrosulphite giving an alkaline reaction, such as sodium hydrosulphite, a grayness develops, but zinc hydrosulphite produces a brightness improvement with increasing temperatures up to approximately 200°F., and the increased temperatures materially shorten the time to attain maximum brightness. For any one treatment and temperature there is a period of maximum brightness and although this period is not particularly critical, the color deteriorates if the temperature is maintained beyond. No change in brightening effect due to consistency within the range 1 to 6% has been found.

Although groundwood treated with zinc hydrosulphite at normal consistencies of 2.5% and up is not particularly corrosive, upon being diluted the corrosiveness increases considerably. The exact cause of the corrosiveness is not known, but undoubtedly sulphurous and sulphuric acids are formed, and these, in conjunction with a reducing action, make the white waters particularly corrosive to metals protected by an oxide coating, such as copper or bronze. Cast iron stands up reasonably well and high chrome steel very well; 18–8 stainless steel does not, but molybdenum stainless seems unaffected.

Obviously then, washing is required to remove the corrosive effect. The ordinary type of pneumatic drum washer was found unsuitable mainly due to an extremely low capacity and therefore it was necessary to develop a washer of high capacity. This was accomplished by the unique method of feeding the pulp, at about 2% consistency or better, to the downward rotating side of the drum of a standard pneumatic washer thereby forming a sheet on the wire ahead of its entry into the vat. The wash water is then added to the vat proper as well as by means of the conventional showers. In this way a full displacement wash with high capacities is achieved. Capacity of the washer varies with the consistency of feed, freeness, and treatment, etc., but a 14 by 8-foot diameter drum, at 0.6% treatment, has a capacity of 125 tons on West Coast grinder stock at 110 Canadian Standard freeness. Wash water amounts to approximately 400 Imperial gallons per minute. The washer also serves to terminate the treatment period allowing a maximum brightening effect.

In the procedure in brightening groundwood for newsprint, the temperature requirements are met by feeding the zinc hydrosulphite into the stock immediately following the grinder where temperatures something like 140 to 150° usually prevail. Since a low per cent treatment, about 0.6% by weight, is all that is required, the retention time at this temperature is only about 20 minutes. After this, the stock is passed through the bull screens and knotters at 2% consistency, washed, and then it proceeds to the screens in the usual manner. White water from the cloudy port of the washer is returned to the grinder room as shower and ditch water for maintenance of temperature and chemical conservation, and the clear port water is effluented to waste. Fresh water or paper mill white water is used for wash water. Such a system is illustrated in Fig. 1. An alternate system in which the washer follows the usual screening system is shown in Fig. 2. In this case a high temperature groundwood system is inferred, and it will be noted that white water effluent from the washer is not returned to the pulp system.

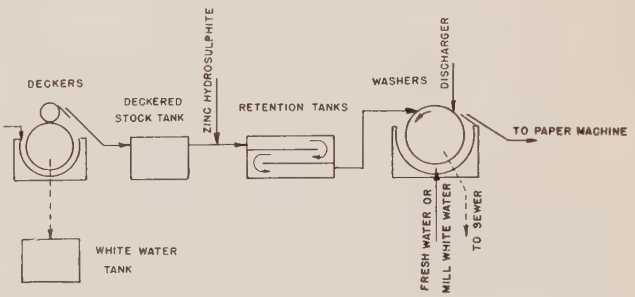

Fig. 2. Brightening at deckers

Where groundwood papers requiring a high brightening treatment are concerned, a chemical treatment of 3 to 4% zinc hydrosulphite, at a temperature of 160 to 165°F., and a retention time of 1.5 to 2 hours would probably pertain and, with the necessity of control for uniformity, the system shown in Fig. 2 would likely give the best results. Furthermore sulphite-groundwood mixtures could be handled and, too,

the washing of the stock could be accomplished immediately prior to its use on the paper machines so as to avoid mill process discoloration and achieve maximum effect.

The effect of zinc hydrosulphite treatments at various temperatures on Pacific Coast groundwoods is shown in Table I. For a comparison, brightness improvement to the maximums shown in these tables, by the use of the sodium peroxide method require 5 to 6% Na_2O_2, by weight, with other factors favorable.

residual chemicals following washing also control the growth.

MANUFACTURE OF ZINC HYDROSULPHITE

Zinc hydrosulphite is manufactured from zinc and sulphurous acid in either a batch or continuous process. Zinc, in the form of zinc dust, is commonly employed. The reaction must be carried out under controlled conditions, and the heat of formation continuously removed. The final product should be kept at a temperature below 60°F., otherwise, loss of strength results; for instance, with a 10% solution, the breakdown amounts to 2.5% of the strength in 24 hours at 75°F. whereas it is only 0.5% at 60°F.

Table I. Increase in Brightness for Various Treatments

Treatment			Brightness					
			Western Hemlock		Sitka Spruce		Balsam Fir	
Zinc hydrosulphite, %	Temperature, °F.	Time, hr.	GE units	Increase	GE units	Increase	GE units	Increase
Original pulp	..	..	53	..	59	..	..	..
0.5	80	2.2	57	4	62.5	3.5	..	..
	140	0.5	58	5	63.5	4	..	..
	180	0.3	58.5	5.5	64	5	..	..
1.0	80	4.0	58.5	5.5	63	4	..	..
	140	1.3	60	7	64.5	5.5	..	..
	180	1.0	60.5	7.5	65.5	6.5	..	..
2.0	80	6.5	59.5	6.5	63.5	4.5	..	..
	140	1.8	61.5	8.5	65.5	6.5	..	..
	180	1.5	62	9	66.5	7.5	..	..
4.0	80	15.5	60	7	64	5	..	..
	140	2.0	62.5	9.5	67	8	..	..
	180	2.5	63.5	10.5	68	9	..	..
Original pulp	..	..	53	..	61	..	56.5	..
4%	165	2	65.5	12.5	72	11	69	12.5

With respect to the effect of aging, West Coast experience has been for aging without exposure to light other than that required for examination purposes, that the rate of color deterioration is about the same as that of normal groundwood, however, the degree of brightness improvement largely persists. As an example of color deterioration, figures on partially brightened stock covering a 3-year period are shown in Table II.

Table II. Effect of Aging on Brightness (Unexposed to Light)

	GE brightness units			
	Western Hemlock		Sitka Spruce	
Time	Original pulp	Treated	Original pulp	Treated
0	54.5	61	59.5	64.5
3 mo.	53.5	59	58.0	62.5
1 yr.	52	57	56.0	60.0
2 yr.	50.5	55.5	54.5	58.0
3 yr.	49.5	54.5	53.5	57.0

Judging from the fact that approximately the same maximum brightness improvement for both the spruce and hemlock results and that original differences in brightness between untreated and treated pulps largely persist with age, it would seem that the zinc hydrosulphite process renders soluble and removes certain coloring matters originally in the wood. Process discoloration is minimized too by keeping iron in the pulp in the ferrous state, thereby allowing it to be removed.

Incidental to the use of zinc hydrosulphite for brightening, it has been found to have a very beneficial effect on slime conditions. This is attributed to the fact that the zinc hydrosulphite treatment in itself apparently retards bacterial development and the

Generally, a sulphurous acid of about 7% SO_2 content giving a 10% zinc hydrosulphite solution is used, but that is not obligatory. However if too dilute a solution is manufactured, efficiency suffers, and if too concentrated, crystallization problems result.

Obviously, in the manufacture of zinc hydrosulphite, a sulphite mill is of considerable advantage in supplying a strong SO_2 solution, relief gas from the digester or acid accumulator providing the strong gas necessary.

The procedure for making a 10% zinc hydrosulphite solution, by the batch system using zinc dust, is briefly as follows. A zinc dust slurry is made in a tank equipped with cooling coils and agitator. To the zinc dust slurry is added sulphurous acid solution of a strength depending upon the desired strength of the final product at a rate that allows for removal of the heat of reaction. Following this, the excess zinc dust and small amounts of zinc sulphite produced are settled out, the excess zinc dust being used in subsequent batches, and the cooled zinc hydrosulphite solution is stored under a film of oil to prevent oxidation. An efficiency of approximately 97%, based on the available zinc, is achieved under proper control.

It will be appreciated that the experience noted was gained in the zinc hydrosulphite process in its application to West Coast woods. It is not known what results would be obtained on species from other areas. However, that may be determined in simple laboratory procedures for it is found that laboratory results are duplicated in practice.

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Progress in Alkaline Pulping

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During the major portion of 1947 not covered by "Progress in Alkaline Pulping in 1946" and the first few months of 1948, numerous articles have appeared in the trade, technical, and scientific periodicals which refer to work or progress made in 1947 or to earlier work or progress which has only recently been reported. Every (*1, 2*) reviewed the growth and outlook of the kraft industry. Wells (*3*) pointed to the phenomenal increase in the use of aspen pulpwood in the Lake States, amounting to 146 times since 1920. Semichemical pulps developed by the staff of the Forest Products Laboratory in 1924 and first applied to the utilization of extracted chestnut chips for corrugating paper now comprises an industry making over 500 tons of product per day. Northern Michigan is particularly well situated for the establishment of integrated semichemical and groundwood newsprint mills and integrated semichemical and kraft board mills. Units of at least 200 tons of newsprint or 400 tons of board and corrugating per day should be considered to obtain the economies of recent progress in paper machinery and recovery room design. Kress (*4*) gave an authoritative survey, backed by a lifetime of experience in the field, and an appreciation of the value of the byproducts heretofore largely wasted. Shorter (*5*) prophesied that the furnishing of kraft wrapping, particularly for specialized uses, will revert largely to the northern kraft wrapping paper mills. A discussion of the excellent opportunities for using kraft by book and picture publishing houses, hotels, tire and automobile manufacturers, celery growers, the cotton industry, construction companies, farms and railway shippers has appeared in *The Paper & Twine Journal* (*6, 7*). Kirby (*8*) attributed the phenomenal growth in tonnage of kraft pulp, as compared with sulphite since 1930, to the late development of the former, the practice of chemical recovery, the use of more widespread and less costly woods, and the superior papermaking properties of the unbleached and bleached pulps obtained. Heath (*9*) pointed out the advantages of the kraft process in the production of cellulose.

EXPANSION IN THE UNITED STATES

Much modernization, expansion, and construction of new mills has been completed. The Champion International Company mill (*10*) has doubled its capacity. The Penobscot Chemical Fibre Company (*11*) has added a 200,000-pound per hour steam generator and a large recovery boiler equipped with scrubber, Cottrell wet-type precipitator, and washers giving 93% recovery of soda. Brown Company (*12, 13*) has finished a new 200-ton sulphate mill for pulping and bleaching hardwoods at Berlin, New Hampshire. The Thilmany Pulp & Paper Company (*14*) has expanded by installing a new paper machine fourdrinier section, a Venturi scrubber, and water-treating plant. The Nekoosa-Edwards Paper Company (*15, 16*), which resulted from the consolidation of the Centralia Pulp and Paper Company founded by F. Garrison in 1887, the Nekoosa Paper Company by T. E. Nash in 1893, and the Edwards Manufacturing Company by L. M. Alexander in 1896, has completed the installation of their bleach plant based upon U. S. patent 1,883,193, which covers the multistage chlorination and bleaching process developed at Nekoosa in 1930. A newly installed Cottrell precipitation process has also started operation.

Great activity is prevalent in the Southern States. The annual directory includes 14 states and Puerto Rico (*17*). The rate of building (*18*) is rapidly nearing the prewar years and may soon double existing capacity. Hardwoods are being used to an increasing extent. The North Carolina Pulp Company (*19*) has increased its capacity from 400 to 700 tons of kraft pulp per day and installed a new Beloit paper machine with a secondary headbox capable of making 500 tons of kraft liner per day. The Champion Paper and Fibre Company at Canton, North Carolina (*20*) has greatly improved and expanded. The story of the West Virginia Pulp & Paper Company (*21*) relates the growth from 30 tons per day 60 years ago to 2000 tons per day in 1948. The Sonoco Products Co. (*22*), the first mill to make semipulp using wood other than chestnut, has added the eighth fourdrinier paper machine and enlarged its pulp capacity to furnish the stock needed. The Union Bag & Paper Company (*23*) has placed in operation its fifth 234-inch fourdrinier paper machine, extended its pulping capacity, installed Cottrell precipitators, and increased its corrugated box capacity to 5000 tons of boxes per month. The Container Corporation of America has greatly augmented and modernized its Fernandina plant with a new 178-inch board machine, additional recovery furnaces, digesters, washers, and evaporators (*24*). A new kraft wrapping paper mill has been added at Palatka to the mills in Florida with a capacity of 200 tons per day (*25*). A new mill and an addition to the existing mill at Pensacola have also been built (*27*). In Alabama, a 350-ton newsprint paper mill and a bleached kraft mill of 170 tons daily capacity is under construction at Childersburg (*26, 28*). The Coosa River project and the part which Kimberly-Clark will play in it have been described briefly (*30*); the plan calls for an annual production of 100,000 tons of newsprint and 50,000 of sulphate pulp. The Gaylord Container Corporation mill at Bogalusa, Louisiana, has increased production to 650 tons of sulphate pulp and 100 tons of semichemical, with facilities to

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utilize 100 tons of waste paper per day. Four new digesters, a new recovery furnace, a fuel-fired steam boiler and turboelectric generator, Cottrell precipitators, and two new brown stock washers are among the improvements added (*31*). The pioneer mill at Orange, Texas, has had its papermaking facilities rebuilt and improved so as to operate between 700 and 1000 feet per minute. This mill together with the kraft mill at Roanoke Rapids were the first integrated kraft pulp and paper mills in the United States and many of the leaders in the industry today obtained their early experience at one or the other of these mills (*32*). Announcement has been made of the planning of a new kraft mill for West Sacramento, California, to cost 14 million dollars (*33*). Three billion feet of timber eminently suitable for the best quality of kraft paper are reported to be available. The Weyerhaeuser Timber Company (*34*) announces a 150-ton kraft pulp and board mill integrated with a sawmill at Springfield, Oregon. A new wood plant (*35*) for the Fir-Tex Insulating Board Company at St. Helens, Oregon, went into production. Semichemical pulp is processed by a Roll-O-Finer to furnish the 15% pulp constituent of the board produced.

EXPANSION IN CANADA

The Wayagamack Division of the Consolidated Paper Corporation at Three Rivers, Quebec, has replaced equipment in the woodroom, washroom, recovery and digester departments with modern and improved equipment that has reduced losses and costs, increased capacity, and improved quality (*36, 37*). The new mill at Marathon is now in full operation (*38*). The new plant of the LongLac Pulp and Paper Company at Schreiber, Terrace Bay, Ontario, together with a new town and the Agnasabon River hydroelectric development, is well under way (*29, 39*). Emmerson (*40*) described (with illustrations) a visit to the mills in British Columbia. Bloch and Granberg, (*42, 43;* cf. *41*) paid particular attention to the mill of Pacific Mills, Ltd., at Ocean Falls. The modernization of the Sorg Pulp Company, Ltd., at Port Mellon (*44*), resulting in a supply of 150 tons of high-grade kraft pulp per day for the Sorg Paper Company mill in Middletown, Ohio was reported. The newest kraft pulp mill in British Columbia (*45, 46*) came into production at Port Alberni, Vancouver Island. The daily capacity is 165 tons of unbleached kraft pulp. Another mill backed by a supply of 150,000 cords per year, is planned for Duncan Bay (*47*).

OTHER COUNTRIES

Mexico's new kraft mill at Atenquique, making 80 tons of kraft paper per day, has been described (*48*).

France's kraft paper industry was discussed by Gooch (*49*).

CONSUMPTION OF CHEMICALS

Skeen (*50*) gave a statistical review of the production of soda ash and caustic soda, setting the consumption of soda ash in 1947 at 4,500,000 tons and of caustic soda at 2,000,000 tons.

Chemical Industries (*51*) stated that, in 1927, the kraft industry consumed 100,000 tons of salt cake, whereas in 1946 the consumption was over 700,000 tons.

Further expansion of the industry will offset the recovery of fume from recovery stack gases now becoming more general. The natural product is the most promising source of increased supply.

WOODS USED

Hart and Strapp (*52*) reported on studies on the alkaline pulping of spruce at the Pulp and Paper Research Institute of Canada. Degree of sulphidity, amount of active chemical, temperature, duration, and dilution with black liquor were the variables studied. The benefits from the activity of the unconsumed chemical in the black liquor reported by Enderlein and Crandall were not observed. Similar studies on red pine were reported by Yeguchi (*53*). Best sulphidities were between 40 and 45%, with the active chemical (calculated as NaOH) between 22 and 23%. Hanson's minimum effective chemical requirement of 15 to 16% was confirmed. The use of 30% active chemical was found to be wasteful and damaging to the fiber. Degradation of the fiber occurred with removal of the lignin down to 4%. With 20% active chemical, lignin cannot be reduced below 7% of the pulp without degradation. Each increase of 10° C. in temperature accelerated the speed of reaction 2.5 times. Lin, Lin, Jen, and Lu (*54*) published similar studies on pulping and bleaching of fir, pine, and bamboo. Bray and Martin (*55*) reported on pulping studies of Douglas fir, western hemlock, Pacific silver fir, and western red cedar logging and sawmill waste.

Experiments at the St. Joe Paper Company (*56*) indicated the suitability of Australian pine (*Casuarina*) grown in Florida for kraft pulping and bleaching for use in book, bond, and mimeograph paper. Cook (*57*) reported on European larch grown in New York and pulped by the kraft and semikraft processes. The pulpwood had wide annual rings and no heartwood. The strength of the pulp approximated that obtained by the use of spruce. Mackin (*58*) reported on book paper and newsprint of very satisfactory strength, freeness, and absorbency made from aspen pulp prepared by the semichemical and groundwood processes. Jayme (*59*) studied the influence of species and site on the pulping behavior and yield of six poplars. Jahn (*60*) discussed the increasing use of hardwoods in Europe, pulping by means of the sulphate and neutral sulphite semichemical processes, Cottrell precipitator as used in kraft mills, and high-yield bleached pulps of superior strength using semichemical pulps. Wood impregnated with chemicals under pressure and then ground with conventional grinders gave high-yield strong pulps.

AGRICULTURAL RESIDUES AND GRASSES

Schaan (*61*) reported that 525,000 tons of esparto can nominally be supplied by North Africa. Lin, Lin, Jen, and Lu (*54*) gave data on the properties and yields obtained when pulping bamboo with alkaline processes. Bhargava (*62*) discussed the manufacture and use of sulphite pulps from bamboo in India. He studied at the Forest Products Laboratory at Madison in the early 1920's and has been active in the paper industry since his return to India shortly thereafter.

Ono, Miyake, and co-workers (*63–65*) gave details of exhaustive studies in Japan on the pulping of bagasse using caustic soda, sodium sulphide, and sodium sulphite. Use of caustic soda in minimal amounts, combined with fractionation of the structural elements of the cane, gives excellent results. The large amount of work performed in recent years seems an appreciation of the feasibility of using bagasse as a source of paper pulp for worldwide supply. Morley and Baker (*66*) have patented a continuous digester for cooking straw with caustic soda at atmospheric pressure. This development has been in use in Great Britain for some time and is now being offered for sale in the United States and Canada. Monsanto Magazine (*67*) discussed the use of byproduct sodium sulphite for cooking straw along the lines used in the late 1920's for the manufacture of Nu Process filler board and Strawkraft corrugating by some of the mills now comprising the Central Fibre Products Company. The use of a commercial grade of sodium sulphite at reasonable price avoids the necessity for each mill to make its own by burning sulphur and absorbing sulphur dioxide in a solution of caustic soda or sodium carbonate. Hannaway (*68*) reported on some results obtained in mill trials. References to earlier investigators would have enhanced the value of the article in the estimation of technical workers and it is regrettable that recognized standards of courtesy are not enforced. Aronovsky, Ernst, and Sutcliffe (*69*) gave the results of some pulping studies on straw, using lime and sodium sulphite. Lower density papers were made with better strength than with lime and caustic soda. Pulps of exceptional freeness were obtained. Aronovsky (*70*) gave a review of the use of straw in recent years, using soda, neutral sulphite and kraft pulping processes. England and Holland are particularly mentioned. A cost of $41.92 per ton of pulp is estimated, using the 1941 scale of prices.

COOKING PROCEDURES AND DIGESTER FACILITIES

McAlear (*71*) described a control system applicable to both direct and indirect cooking, with control and indicating instruments on a central panel. McGlothlin (*72*) announced a new pressure control for a rotary and tumbling digester. Richter (*73, 74*) disclosed means for heating and controlling the temperature in a continuously operating digester with indirect heating. Messing and Durkee and Beveridge and Kehoe (*75–77*) disclosed continuous digesters and pulping processes. Wells (*78*) presented a process which makes use of preliminary impregnation with black liquor, followed by continuous injection of active alkali under conductometric control to avoid concentrations that damage the cellulose and thus obtains increased yields, greater strength, and easier bleaching without an increase in the duration of cooking. Tarkkonen (*79*) discussed how steam requirements may be reduced by decreased liquor volume and inert solids in the liquor, and the use of black liquor and the flash steam therefrom from blowing one digester in the charging of the next. Murto (*80*) reported on two-stage hydrolysis of sodium sulphide at room temperature, sulphur balance in mill operation, and pre-impregnation with black liquor. Hägglund (*81*) discussed the merits of higher sulphidities and the damage from bruising chips in chipping. He also reviewed the work of the Central Chemical Laboratories on lignin, pulping, and bleaching (*82*). Bray and Singer (*83*) discussed the value and influence of sodium sulphite and thiosulphate as a substitute auxiliary to sodium sulphide in kraft pulping of Engelmann spruce. Merits not recognized in earlier work were claimed. Björkman (*84*) presented factors governing the blowing of digesters and attributed much influence to the kraft soap present. Tufts (*85*) pointed to the use of vibrators for removing wood chips from metal bins. Craig (*86*) showed that cooking by the semichemical process in rotaries or mechanical defiberization and reduction of the product with rods in the presence of dilute warm caustic soda solution yields fiber much more adaptable, more flexible, and more useful than high-yield pulps produced by other methods.

FOAM

Young (*87, 88*) disclosed means for preventing foam difficulties in countercurrent washing by directing a stream of the liquid and foam at high velocity against the main stream, thus breaking the bubbles.

WASHING

Hannan (*89*) stated that open-top diffusers give more rapid washing than closed diffusers but are more subject to channeling. By blowing into a blow tank and pumping into open pans, the brown stock can be deposited so that channeling is avoided. Gralén (*90*) discussed the probable error in diffusion calculations. Gavelin (*91*) described diffuser and rotary filter washing.

EVAPORATION

Badger and Lindsay (*92*) reviewed the literature on evaporation during 1947, giving 46 references. Caldwell and Kohlins (*93*) discussed how the number of effects chosen in multiple-effect evaporation should be governed by the cost of steam. A solution for the metering of black liquor is described in *Instrumentation* (*94*).

TALL OIL AND TURPENTINE RECOVERY

Interest in the recovery of tall oil and its purification and application to many products and uses is much greater than ever before. Kress (*95*) described the recovery and enumerated the uses to which tall oil and turpentine have been devoted. Matagrin (*96*) presented a thorough review of methods of analysis and the composition of spent pulping liquors, methods of utilization, recovery, and uses of byproducts with 231 footnotes. Reed (*97*) described the methods of collection and purification of tall oil as practiced by the National Southern Products Corporation at Tuscaloosa, Alabama. Pollak and Wiley (*98*) discussed the fuel and soda values of skimmings as compared with its value as a source for various products. Powers (*99*) stated that the production of sulphate turpentine almost equals that of gum turpentine. Chemical industries are large users. The Foster Wheeler Corporation (*100*) gave the flowsheet for turpentine re-

covery, showing cyclone-type separator, surface condenser, final turpentine separator, and decanter. Yields of 1.5 to 4 gallons per ton of pulp are reported. Larinkari (*101*) described the use of kraft turpentine for making flotation oil. Vaughn (*102*) reported the activities of the Swedish pulp companies in the manufacture of byproducts for use as chemicals.

Coons, Hargis, Hewes, and Weems (*103*) reported studies on the flow of fluids and heat-transfer coefficients in spiral heat exchangers. Tall oil thinned with kerosene was one of the fluids used and an increase of 35% in heat transfer over straight tube units was noted. According to an article in *Chemical Industries* (*104*), the production of tall oil in the United States may reach 125,000 tons in 1947. Jennings (*105*) discussed seasonal and geographical variations in the composition of tall oil. Geographical distribution is more important than seasonal changes.

Dern (*106*) reviewed the nature, composition, recovery, and purification of tall oil as reported by investigators outside of France. Juvonen (*107*) reviewed the subject, giving 48 references. Rooney (*108*) reported on the utilization of tall oil in Germany. Reppe (*109*) summarized the researches of the I. G. Farbenindustrie in the field of synthetic acids and drying oil, mentioning vinyl esters of tall oil acids. Noll (*110*) gave the composition of German and Scandinavian products. Hess (*111*) described the origin, composition, and processing of tall oil and its uses in the paint industry.

Palmer (*112*), Freeman and Gloyer (*113*), Jayne (*114*), Martin (*115*), and Bent and Peterson (*116*) have disclosed methods of purification of tall oil in which esterification is used.

Harwood and Birkerd (*117*), Pollak, Chapman, and Hastings (*118*), Houpt (*119*), Harris (*120*), Huff (*121*), Kalman (*122*), Babayan (*123*), and Harva (*124*) disclosed other methods for refining and separation of constituents. The recovery of phytosterol was announced in *Chemical and Engineering News* (*125*) and by Enkvist (*126*) and methods for its use in the manufacture of sex hormones are discussed. Enkvist (*127–129*) gave the results of studies of tall oil, pitch, and pine tar for many uses, including lubricating oils. Bare and Stubblebine (*130*) disclosed its treatment and use for linoleum cement and La Crosse (*131*) its use with butadiene-styrene for reinforcing rubberlike compounds. Woerner (*132*) described its use as a drying oil ingredient. Bergström, Heijmer, and Trobeck (*133*) announced the use of a fraction from vacuum distillation for indurating boards. Johnson (*134*) disclosed the use of amines produced therefrom for promoting the adhesion of bituminous products to wet road and other mineral aggregates. Herkenhoff (*135, 136*) and Clemmer and Rampacek (*137*) have patented methods for its use as agglomerating, flotation, and collecting agents in the beneficiation of metal- and silica-containing ores.

TESTING METHODS

The Pulp and Paper Magazine of Canada (*138*) and Driessen (*139*) described the control laboratories of the Sorg Pulp Company, Ltd., and the Pacific Mills, Ltd., and control at the Thilmany Pulp & Paper Company, Provan, Scorgie, and Harrison (*140*), Edmonds (*141*), and Young and Jones (*142*) discussed conductometric and other methods for analysis of alkaline cooking and spent liquors. LaPietra (*143*) reviewed and summarized methods for the analysis of alkali sulphur compounds. Collins (*144*) reviewed the literature on sampling and analyzing sulphate recovery stack gases. Enkvist (*145*) discussed methods and results of analysis of volatile sulphur compounds in sulphate turpentine. Snell (*146*) described and discussed methods for the determination of acid, saponification, and rosin acid values of tall oil. Sprengling (*147*) described a modification of the Hastings and Pollak method. Pollak, Wiley, and Taylor (*148*) have compared electrometric with colorimetric methods.

RECOVERY OPERATION AND EQUIPMENT

Hamm (*149*) disclosed the recovery furnace system used by the Combustion Engineering Company. Allen (*150*) described the developments in design and performance of recovery furnaces and boilers with special reference to the B & W-Tomlinson unit. Edling (*151*) discussed recovery furnace and boiler practice, stating that a net heat recovery (in steam) of 65% of the calorific value of black liquor is often attained with additional heat recovery by heating water. Dzhaparidze (*152*) discussed the reactions known to occur in the recovery furnace of the sulphate mill. Tomlinson and Tomlinson, Jr. (*153*) and Tomlinson, Jr. (*154*) disclosed the stepwise precipitation of alkali lignin and the developments at the Howard Smith Paper Mills. Keilen and Pollak (*155*) described the use in and improvement of natural and synthetic rubber products by the use of thiolignin in compounding. Goodell (*156*) disclosed the recovery of organic compounds, such as phenols, from the distillation of spray-dried black liquor. Johansson (*157*) discussed the dry destructive distillation of black liquor from soda pulp mills. Brohmeyer (*158*) reported the use of residues from the destructive distillation of black liquor in the decomposition of phosphate rock, desulphuring and reduction in the iron and steel industry, and as a source of soda and reducing carbon in the manufacture of glass. Galtsoff, Chipman, Engle, and Calderwood (*159*) discuss the effect of sulphate pulp mill wastes on oyster culture in the York River, Virginia. Collins and Collins (*160*) reviewed the literature on losses in soda and sulphate recovery systems. Collins, Seaborne, and Anthony (*161*) described the recovery of fumes from recovery stack gases by use of the Venturi tube scrubber to the extent of 99%. Collins (*162*) described the operation of the Venturi type scrubber at the Thilmany Pulp & Paper Company.

Clemens (*163, 164*) reported recent developments in the Dorr continuous recausticizing system. Nepenin (*165*) discussed the effect of sodium sulphide and sodium sulphate on the rate and degree of causticization of green liquors. The figures are lower throughout than those of Hughey, Herndon, and Withrow (*166*).

Azbe (*167*) discussed the benefits of the orderly arrangement of heat transfer in vertical and rotary lime kilns, insuring high capacity and fuel efficiency.

Tock (*168*) stated that progressive improvements in design and operation have resulted in efficient recovery. Collins (*169*) reported that the average loss of 79 pounds of lime dust per ton of pulp produced may be reduced 70%, with an additional saving of 5 pounds of salt cake, by the use of Multiclone separators and that the use of the exit gases for raising the temperature of the saturated gases from the scrubber of the recovery room stack would mean additional economies. Ginodman (*170*) and Hemeon and Hatch (*171*) discussed the purification of relief and stack gases in sulphate pulp manufacture and the factors involved in the abatement of atmospheric pollution.

PURIFICATION AND BLEACHING

The volume of bleached kraft pulp produced has continued to grow rapidly and extensively. Sprout and Toovey (*172*) indicated that, in addition to the recognized merits of various procedures in multistage chlorination and bleaching, the use of two or three stages of chlorination in series with counter application has considerable merit in saving time and accomplishment. Simmonds and Kingsbury (*173*) and Trivedi, Kingsbury, and Simmonds (*174*) discussed the multistage purification and bleaching of aspen neutral sulphite semichemical pulps. Wurz (*175*) reviewed high density systems such as the Thorne, Belmer and Kamyr, and stated that although more feasible economically, the Hollander bleacher and drum washer is still capable of producing the best results in respect to quality of product. Wenzl (*176*) gave a comprehensive review of the literature on bleaching (75 references) and the results of bleaching studies on quick-cook and Mitscherlich sulphite pulps and sulphate kraft pulps of 40, 50, 60, and 70 Roe numbers to show the best combination of stages using chlorine, hypochlorite, and chlorine dioxide in combination or separately, and the relative merits of using chlorine or chlorine dioxide at particular stages. Herman Wenzl was a collaborator with Dr. Schwalbe in the early 1920's when modern bleaching processes were first being evolved. Vincent (*177*) pointed out the advantages and operating economies of the use of chlorine as an agent for the release of chlorine dioxide from sodium chlorite for at least the final stages in the bleaching of pulps produced by alkaline processes. Levy and Brennan (*178*) disclosed the use of soluble salts of cobalt, nickel, copper, or manganese to obtain a high viscosity and copper number relationship when bleaching sulphate pulps from flax. Casciani (*179*) disclosed the use of hypochlorite for the first stage, excess of chlorine for the second stage, followed by neutralization with milk of lime after a few minutes, exhaustion of the hypochlorite formed, and a final bleach. He claimed that a kraft pulp with a brightness of 21 and a cuprammonium viscosity of 68.5 was converted to a pulp having a brightness of 83.3, a viscosity of 19.2, and an α-cellulose content of 86.8%. Oliver (*180*) claimed that fibers of exceptional brilliance and freedom from incrustants can be made by a cold bleaching process using a hypochlorite and a preformed inorganic glucosate. Aggarwala (*181*) reviewed the bleaching of wood pulp (17 references) and Lin and Jen (*182*) reported on the bleachability of pulps from fir, pine, and bamboo.

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Process Water for the Manufacture of Alkaline Pulps

LEWIS B. MILLER

THE DATA assembled in TAPPI Special Report No. 375 and summarized here were obtained from a questionnaire distributed to the producers of alkaline pulp. Sixteen replies were obtained from sulphate (kraft) pulp producers and three replies from soda pulp producers. The summarized results represent the data obtained upon sulphate pulp production since it is considered that the data upon soda pulp production are too few to be of significance.

RAW WATER SUPPLIES

The raw water supplies are obtained from rivers, lakes and wells. Of the contributing mills six used well waters wholly or in part, eight used river water, and two used lake water. Eight of the mills report the water supply contaminated in varying degrees by sanitary sewage and/or industrial wastes.

For treating the raw water to prepare it for process use ten mills use mechanical treatment. The methods utilized include settling basins or ponds, screening, and filtration. Eight mills report the use of chemical treatment. Of these three coagulate the water with chemical coagulants; six treat by means of chlorine or chloramine.

Turbidity

Raw waters range from 0 to 5000 p.p.m. of turbidity; process waters vary from 0 to 125 p.p.m. turbidity. Permissible upper limits of turbidity for process water reported by different mills are 20 p.p.m., trace, 100 p.p.m., trace, 35 p.p.m., no set limit.

Suspended Solids

Raw waters range from 0 to 5000 p.p.m. of suspended solids. Process waters vary from 0 to 30 p.p.m. Permissible upper limits reported are as follows: 10 to 30 p.p.m., 2 p.p.m., 20 p.p.m., trace.

Hardness (as p.p.m. $CaCO_3$)

Raw waters vary from 0 to 266 p.p.m. in total hard-

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ness, process waters from 0 to 260 p.p.m. Upper limits set by different mills are as follows: 34 and 80 p.p.m.

Manganese (as p.p.m. Mn)

Raw waters range from 0 to 0.025 p.p.m. Process waters are uniformly reported as containing no manganese. No upper limits are reported probably because the mills reporting found substantially no manganese in the raw water supplies.

Calcium (as p.p.m. $CaCO_3$)

Raw waters vary from 1 to 200 p.p.m. in calcium content. Process waters show a similar range of variation. Permissible upper limits are reported as 30 p.p.m., 28 to 30 p.p.m.

Magnesium (as p.p.m. $CaCO_3$)

The magnesium content of raw waters is found to vary from 1 to 102 p.p.m. Process waters range from 1 to 16 p.p.m. Permissible upper limits set by different mills are as follows: 8 to 10 p.p.m.

Aluminum (as p.p.m. Al)

In raw waters the aluminum content varies from 0 to 7.0 p.p.m.; in process waters the same variation is noted. One mill places a permissible upper limit of 1.0 p.p.m. for this constituent in process waters.

Iron (as p.p.m. Fe)

The iron content of raw waters ranges from 0 to 1.9 p.p.m. Process waters vary from 0 to 1.9 p.p.m. Two mills place upper limits upon the iron content of process waters as follows: 0.1 and 1.4 p.p.m.

Color (expressed in color units of platinum)

Raw waters show variations of 0 to 600 color units. Process waters vary over a similar range. Two mills specify permissible upper limits for color as follows: 40 and 600 color units.

Total Solids (in p.p.m. after drying at 105°C.)

Raw waters are reported to vary between 9 and 386 p.p.m. in total solids. Process waters range from 40 to 386 p.p.m. in dissolved solids content. Permissible upper limits are specified as follows for the total dissolved solids content of process water: 60, 123, and 300 p.p.m.

Alkalinity (as p.p.m. $CaCO_3$)

Phenolphthalein Alkalinity

Raw waters and process waters are reported as carrying no phenolphthalein alkalinity.

Methyl Orange Alkalinity

Raw waters vary from 0 to 214.6 p.p.m. Process waters range from 0 to 214.6 p.p.m. A permissible upper limit is specified by two mills as follows: 32 and 80 p.p.m.

pH (expressed in pH units)

Raw waters are reported to vary in pH from 6.3 to 8.2. Process waters vary from a pH value of 6.3 to a value of 7.85. Permissible upper limits of pH are specified by two mills to be values of 6.9 and 7.2.

Sulphates (expressed as p.p.m. SO_4)

Sulphates in raw waters range from 0.8 to 236 p.p.m.; in process waters from 1.2 to 47 p.p.m. Permissible upper limits are specified by two mills at 3.6 and 8.0 p.p.m.

Chlorides (as p.p.m. Cl)

Raw waters vary from 1.0 to 200 p.p.m.; process waters from 1.0 to 72 p.p.m. Permissible upper limits are set by two mills at 1.8 and 3.0 p.p.m.

Silica (as p.p.m. SiO_2)

The silica content of raw water ranges from 1 to 60 p.p.m. Process waters show a range from 3.2 to 55 p.p.m. Permissible upper limits are specified by two mills at 5.0 and 19 p.p.m.

Organic Matter (in p.p.m.)

Raw waters range from 0 to 61 p.p.m. Process waters range from 0 to 61 p.p.m. Permissible upper limits are specified by two mills at 15 and 61 p.p.m.

Total Dissolved Solids (in p.p.m. after drying at 105°C.)

Raw waters vary from 8 to 386 p.p.m.; process waters are reported as varying from 29 to 386 p.p.m. A permissible upper limit of 123 p.p.m. is set by one mill.

CONSTITUENTS MOST IMPORTANT TO CONTROL

These are listed as: suspended solids, pH, carbonates, color, iron, calcium, silt, organic matter, silica, H_2S, iron, hardness, turbidity, alkalinity, oil. These constituents no doubt indicate the water problems encountered at different mills.

The reasons for controlling the objectionable constituents are presented in detail in TAPPI Special Report No. 375 and will not be repeated here. The interested reader should refer to Special Report No. 375.

SLIME AND ITS EFFECT

The effect of biological slimes on alkaline pulp production is presented in the original report together with detailed data upon the amounts and types of chemicals used for control. Chlorine and chloramine appear to be the preferred treatment. There was little response to a question in regard to the losses (in dollars) encountered due to the presence of these slimes. One mill estimated its losses in this respect to lie between $5000 and $10,000 annually.

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Coating Conference Luncheon held at the Hotel Pantlind, Grand Rapids, Mich., April 27, 1949

TAPPI Coating Conference

About 300 representatives of the coated paper industry and its suppliers gathered at the Pantlind Hotel at Grand Rapids, Michigan for the coating conference sponsored by the Kalamazoo Valley Section and the Coating Committee of the Technical Association of the Pulp and Paper Industry that was held Tuesday and Wednesday, April 26–27, 1949.

The first session was opened by P. W. Bartholomew, Technical Director, Hawthorne Paper Co., Chairman of the Kalamazoo Valley Section and General Meeting Chairman, who introduced A. E. Bachmann, Vice-President, Missisquoi Corp. and President of TAPPI. After an expression of appreciation for the assistance of the Kalamazoo Valley Section in arranging the conference, and the services rendered by the Coating Committee to the association and to the coated paper industry, Mr. Bachmann turned the meeting over to Werner Kaufmann, Vice-President, Kupfer Bros. Paper Co., Chairman of the Coating Committee and to W. A. Kirkpatrick, Technical Director, Allied Paper Mills, chairman of the technical program.

The first speaker was Glenn Davidson, consultant and distributor of soy protein adhesives. In his paper, "A Tentative Hypothesis Explaining the Mechanism of Binding Clay Coatings to Paper," he developed a mechanical adhesion theory to explain the Singleterry zone of failure. Curtis Singleterry (Tech. Assoc. Papers 25: 641–644) noted that the adhesion failure of coated paper was usually in the coating in a layer adjacent to the raw stock rather than at the actual contact area (clay-paper interface). This was substantiated by Mr. Davidson who developed the hypothesis that as the clay-adhesive-water mixture flows into the surface cavities of the stock, the adhesive and water are taken up by the sheet by preferential absorption through the capillary openings leaving the clay on the surface. The water is absorbed by the surface fibers which causes them to swell thus closing the openings, and coupled with an increase in viscosity due to the loss of the vehicle, prevents further absorption of the coating mix resulting in the formation of "keys" in the surface voids to bind the coating to the stock. The redistribution of the adhesive caused by its migration leaves a deficiency in the coating just above the contact area and it is this zone to which Singleterry's name is appended. Any treatment on the raw stock which hinders the absorption of the vehicle prevents the formation of the keys and so tends to weaken the bond at the clay-paper interface rather than in the coating.

It was noted that the pick test increased with increase in pH and this was attributed to a better and quicker wetting of the fiber leading to less migration of the adhesive.

With a coating applied in two layers it may be possible to increase the adhesive content of the one adjacent to the stock and minimize coating failures. However, with both applications at the same adhesive content, there is probably the tendency for both to level out giving the same effect as the single application.

The opinion was given that the effect of chain length and orientation of the molecule (linear or globular) on adhesive penetration was mechanical, that is it affects the tendency of the adhesive to block the capillary openings. However, this was questioned as oversimplifying the problem by neglecting the chemical bonding effects.

If wetting of the fiber by the water in the vehicle causes it to swell and thus block the capillary openings, why not prewet the sheet. It was pointed out that the loss of the water from the vehicle that wets the fiber causes an increase in the viscosity of the coating which tends to slow down adhesive penetration into the sheet. This action would not take place if the fibers were already wet.

In his second paper, "Method of Testing Coated Paper for Resistance to Picking on Printing Presses," Mr. Davidson showed graphically the stresses in the wax set up when it is cooling during the pick test. As the wax cools, it contracts, consequently, the test indicates the resistance of the coating to compression and not necessarily bonding strength. This accounts for the satisfactory and unsatisfactory adhesive bond of two different sheets having the same pick test, and the ineffectiveness of the wax test on coatings that

contain a resilient plastic material. Mr. Davidson developed an ink tack apparatus on the printing press principle. The paper to be tested is wrapped around a rotary cylinder under which are variable speed rolls. An ink of definite tack is placed on a plate (pivot block) which is held at constant temperature on a hot plate. After the ink has been brought to temperature the pivet block is fed between paper covered rolls and the driven rolls, the speed of which having been previously adjusted. By trial and error the speed at which the paper picks is determined thus giving a test value in revolutions per minute. By use of this apparatus, significant variations were found in sheets having the same pick test. With a wide range of results on the same type coated sheet it is evident that in the low tests not enough adhesive is provided while if too high it is going to waste.

In response to questioning Mr. Davidson stated that by using the heated plate technique, it was possible to hold the temperature of the ink to within 1 to 1½° during the test. His results were reproducible in that range but difficulty was experienced when there was a temperature variation of over 5°.

During the discussion it was indicated by the floor that the ink tack test also was not infallible as a measure of printability, especially when the paper was run on a high-speed press.

After lunch Professor A. H. Nadelman of Western Michigan College described briefly the facilities of the college and the new course on papermaking. It is expected that they will accept about 30 students a year for a 4-year course leading to a B.S. degree.

William R. Willets of the Titanium Pigment Corp., presented his paper "Titanium Pigments in Coating." Briefing over the properties of titanium pigments, Mr. Willets indicated their use wherever an improvement in optical properties was desired. Better printing qualities are also obtained. Based on laboratory work a ratio of 2½ calcium base pigment in which the TiO_2 is of the rutile type is equivalent to 1 part titanium dioxide of the anatase type. The cost and degree of improvement will vary with the product, but figures of 2 to 8 dollars per ton of paper or 1 to 3 dollars per ton of board were cited as typical.

In discussing the paper it was pointed out that the anatase water-dispersant grade of titanium dioxide was the most widely used. If a paint grade or the rutile type is used it may be necessary to disperse it: 1 to 1½% gum arabic based on the pigment is very effective.

Generally the rutile pigment with the calcium base is more economical than a mixture of clay and anatase titanium dioxide. However, caution must be used if materials reactive with calcium are also in the formulation.

The final speaker on Tuesday was G. F. Blasius, Director of the Burgess Pigment Co., who presented the paper prepared by M. S. Burgess, President of the same company and himself, "Georgia Clays—Their Refinement and Use in the Paper Industry." The Georgia clay belt was described in reference to its location, thickness, type of clay, etc. Mr. Blasius then outlined the steps in the development of a mine and in mining technique: first, random prospecting followed by systematic drilling and sampling to establish the extent of the property and the quality of the clay. Then the mine must be opened by removing the overburden which may range from 20 to 120 feet in thickness. Modern equipment has supplanted manual labor and mule haulage to help reduce costs. During the mining operation it is necessary to constantly sample and analyse the deposit being worked to assure quality. The final stages involve refinement by either the water wash method (coating clays) or air flotation (filler clays), bleaching with a hydrosulphite to reduce the iron content, drying, and packaging or preparing for shipment in dry bulk or in a slurry. Extreme care is taken during drying to prevent the formation of difficulty dispersible agglomerates. The slurried type is shipped at 70% solids and has better uniformity, easier to handle, less storage space required (½ of that needed for dry clay), has a little lower adhesive requirement, gives a higher gloss, and increases the life of supercalender rolls by perhaps as much as 50%. However the use of clay in this form may not be economical for a mill with a low clay requirement.

In the evening on Tuesday, there was an informal banquet in the ballroom which was adjourned to permit the gathering to attend a play "John Loves Mary" which was presented by the Grand Rapids Civic Players.

"Some Consideration with Respect to Soybean Protein" by N. R. Gotthoffer, of the Drackett Co., was the first paper on Wednesday's program. Soybeans have been cultivated since before the birth of Christ, and at the time of World War I some 3000 varieties were known. They were first introduced in the South but now the concentration is in the North Central States. The first consideration in the manufacture of an adhesive from the soybean is how to remove the oil and not damage the protein. The protein must then be dissolved which process involves the use of an alkali and usually also removes the carbohydrates. Precipitation is accomplished with an acid. The resulting protein is greatly affected by the means used for its separation so there can be a large number of types of various characteristics. The commercial grades are now primarily differentiated between by the viscosity of their solutions; one grade being produced can be used in a coating mixture with a solid content of 68%.

The protein molecule is said to be globular or coiled which does not infer surface smoothness or regular arrangement of molecular chains. The treatment to extract the

(continued on page 46 A)

Speakers Table at the Coating Conference Luncheon—left to right: W. A. Kirkpatrick, Allied Paper Mills; Dr. Werner Kaufman, Kupfer Brothers; A. E. Bachmann, Mississquoi Corp.; B. R. Cancell, St. Regis Paper Co.; P. W. Bartholomew, Hawthorne Paper Co.; Dwight Stocker, Michigan Paper Co.; Robert Buss, Hercules Powder Co.; Victor Burstein, Michigan Paper Co.; and Richard T. Bingham, TAPPI

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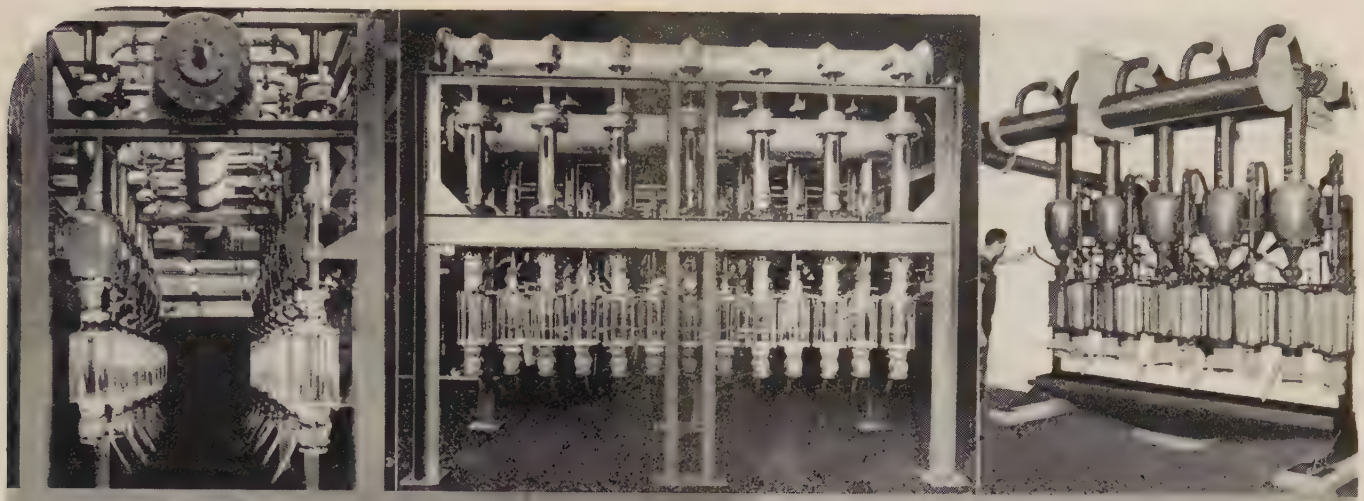

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Dirtecs are demonstrating in mill after mill that they are the happiest solution to the dirt problem, whatever the amount and character of the dirt in the stock, and whatever the kind and volume of stock.

Dirtecs are easy and economical to install and operate. They get the dirt and get it out of the papermaking system for good and all.

Before you do anything else about the demand for cleaner paper, find out what Dirtecs can do for you.

BIRD MACHINE COMPANY

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(continued from page 44 A)

protein tends to make them linear with the probable result of lowering solution viscosity.

Off-color is a property of soy proteins that has hindered their use by the coated paper industry and is attributed to two portions termed enzymatic and nonenzymatic. On the basis of experimental work, protein is believed to be white so the problem of color removal involves the inhibiting of the enzymes and removal of the nonenzymatic fractions which includes the carbohydrates. The browning of dextrine by heat is a simple example of discoloration caused by carbohydrates. Technical advances have been made and it is expected that there will be further refinements.

In coating mixes, an increase in pH has a tendency to increase adhesion and decrease viscosity. The selection of the cutting agent involves specific working characteristics as for instances caustic has a greater effect on viscosity, ammonia and borax give a better color, and ammonia is best when increased water resistance is desired.

During the discussion the question was raised as to why the industry was interested in "viscosity" when it was "fluidity" with which they were primarily concerned. Consideration should be given to adherence to the scientific definition of these effects.

The paper following, "The Effect of Dow Latex 512 K on Starch-Clay Coated Papers" by E. K. Stilbert, R. D. Visger, and R. H. Lalk of the Dow Chemical Co., was primarily concerned with the aging effects when this type of adhesive is used in coating. Experimental and commercial coatings containing latex and starch were examined for wet rub, flexibility, ink receptivity, pitch, and brightness as they are affected by age. Some of the tests were accelerated by use of heat and direct light.

Age increased the wet rub test but it was noted that the presence of calcium carbonate retarded the effect as well as affecting adversely the flexibility more so than clay. In general the results followed the same pattern as one would expect for casein so there is no reason for concern when latex is used. Latex does however, degrade under direct light.

The luncheon Wednesday noon featured B. R. Cancell, General Manager of the St. Regis Paper Co. He was introduced by Dwight Stocker, President of the Michigan Paper Co., who remarked on the increasing cooperativeness of the coated paper industry. Mr. Cancell taking "Research and the Place of the Technical Man in the Paper Industry" as his subject, stated that in this time of setback demand, in contrast to the war period, an organization analysis is required since a depression period always shows up the relative efficiency of a plant. In such a period research should be increased: fundamental in educational institutions and market and product in the mills.

The development of paper machine coated papers has involved but few basic materials so that they have been easily duplicated. However, while these papers, with improvements in inks and the printing presses, have opened a new market for paper, still further developments must be made.

During the past few years such innovations as new synthetic adhesives, the semichemical pulping process with its high yields and use of hardwoods, and a bleaching process for groundwood are attributable to the technical staffs of the mills although it is not generally recognized by management.

In the future, paper will be sold on merit and although sales may be considered a function of the sales department it must be accompanied by the cooperation of the technical department in sales service and in the production of special papers.

(continued on page 48 A)

For pumping corrosive liquids such as acids and alkalis

Here are 3 Reasons WHY I-R CHEMICAL PUMPS WILL GIVE YOU BETTER SERVICE

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A special, proven alloy that will successfully resist the corrosive action of most acids and alkalis. (Other materials are available)

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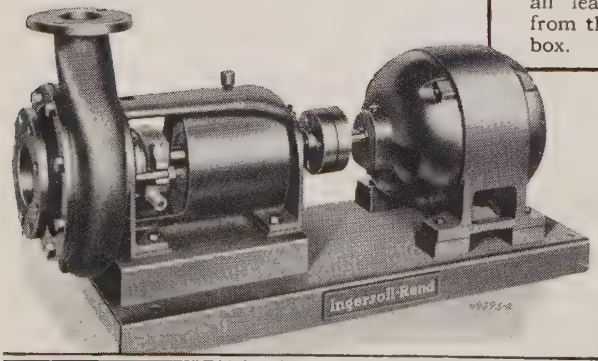

THE CAMERON SHAFT-SEAL, Ingersoll-Rand's modern solution to stuffing-box problems, can be installed on all I-R chemical pumps.

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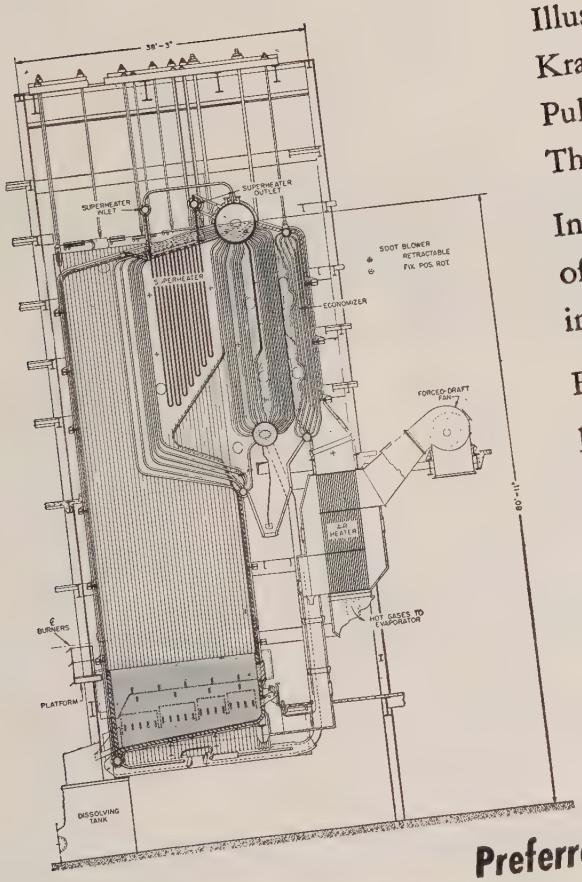


Illustration shows a 250-ton B&W Kraft Recovery Unit, purchased by West Virginia Pulp & Paper Company in December, 1947. This unit is now in process of erection.

In October, 1948, two similar units, each of 250 tons capacity, were ordered, and are now in the B&W shops.

Back in December, 1936, this customer purchased a 120-ton unit, which is still in operation. And four years later, a 200-ton unit was purchased. West Virginia Pulp & Paper has thus, during 12 years, purchased B&W Recovery Units totalling 1070 tons capacity per day.

Preferred on 8 out of 12 new contracts of 1948

P-35

B&W

BABCOCK & WILCOX

D. Robert Erickson presented the first paper in the Wednesday afternoon session entitled "A New Coating Process." The subject was introduced by an enumeration of the desirable characteristics of a coated paper which includes smoothness, compressibility, flexibility, opacity, brightness, sufficient adhesive strength, and ink absorbency, all achieved with a continuous film. In the conventional coating methods, both on and off the machine, the surface after coating is still rough so that supercalendering is required. This process while smoothing the surface tends to crush the sheet thus lowering the adsorbency, an important property for sheets to be used on high speed presses.

By substituting a certain hydroxyalkyl ether of cellulose as the adhesive in an amount equalling 7% on the weight of the pigment it is possible to obtain a smooth, porous coating that does not require supering. The principle of the process is that these new materials, which incidentally are not yet on the commercial market, are selectively soluble in a certain critical concentration of aqueous sodium hydroxide solution and in no other solvents. After the coating is applied, the surface is dampened with a salt such as ammonium sulphate that affects the adhesive solution balance and causes the ether to precipitate thus binding the coating to the sheet. After "fixing" the coating is nontacky and will not stick to the driers. It is expected that it will be possible to use this new coating combination on any type of coating equipment but it is suggested that the "fixing" unit be located as close to the "smoothing" element as possible to prevent excessive absorption of the coating into the sheet.

The basic material is not thermoplastic and has rheological properties similar to starch. It is unaffected by the choice of pigments but a good dispersing agent will be required for high-solid mixes. So far, none have proved satisfactory. The cost is expected to be between that of casein and starch based on the finished product. Coloring of the coating is possible but dye or pigments that are not affected by caustic are required. Without pigmentation, a greaseproof sheet may be produced.

In regard to the possibility of a buildup in the "fixing' process, the ammonium sulphate reacts with the caustic to form sodium sulphate which precipitates out in the treatment bath.

The utilization of broke is not a factor inasmuch as caustic, a commonly used alkali used in deinking, is the solvent. The adhesive reverts to an insoluble precipitate that acts as a filler upon altering the chemical balance.

The final paper of the technical program "The Microjet and Syncroset Coaters," by B. R. Newcomb and C. A. Dickhaut, was presented by Mr. Newcomb.

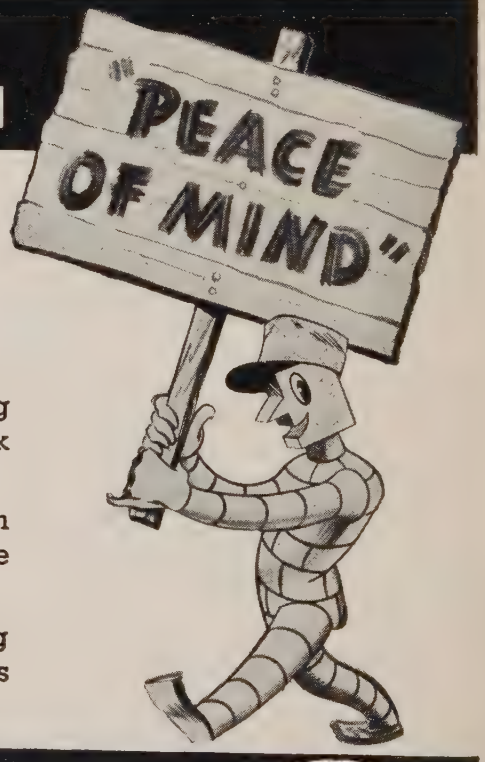
The Microjet coater is of the air brush type which removes the excess coating applied by the application roll by a blade of air the pressure of which and the angle of impingement can be altered to give desired coating weights.

The Syncroset coater is of the rotogravure type in which the coating is applied by an application roll to an engraved roll, the excess doctored off, and the coating remaining in the "wells" of the engraving transferred to a rubber covered offset roll that applies the coating to the sheet. Coating weight is adjusted by the depth of the well and by changes in formulation. The use of a rubber covered offset roll as the offset unit decreases any likelihood of a pattern in the coating.

Both type units have been used very successfully by the industry on many types of products, however, it is believed that the air brush type is the more versatile.

The conference was officially closed with the presentation of the last paper, but through the courtesy and cooperation of the mills in the Kalamazoo area, it was possible for the group to make mill visits on Thursday. The companies which extended invitations included Michigan Carton Co., Battle Creek; American Box Board Co., Grand Rapids;

A STEBBINS LUMP SUM CONTRACT IS AN INVESTMENT IN



Whether the contract covers one chest or tank lining, or all the corrosion or alkali resistant linings for the entire mill, it is Stebbins responsibility to provide a dependable and satisfactory job that assures continuous operation.

- Sixty-five years experience in designing, installing and servicing linings in pulp and paper mills is back of this contract.
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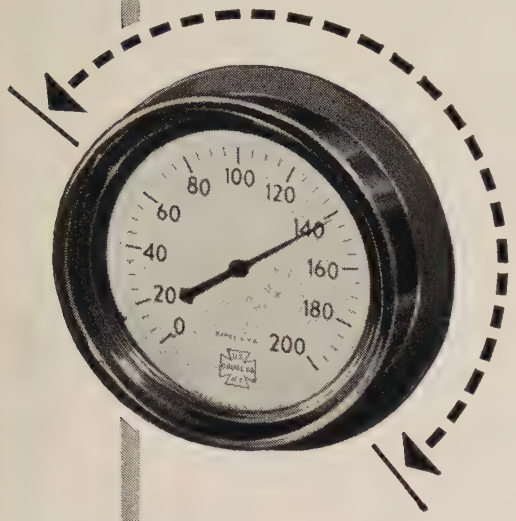
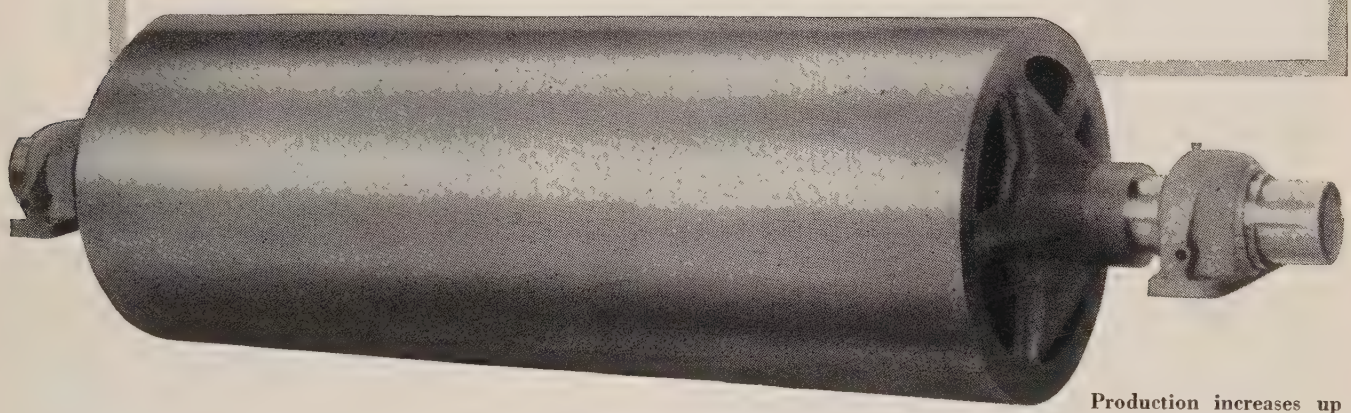


CAN YOU *safely* WORK YOUR DRIER ROLLS AT Higher Steam Pressures?



Production increases up to 60% have been reported after Lukenweld Jacketed Steel Drier Rolls, operating at elevated temperatures, have been installed.

High pressures, possible with Lukenweld Rolls, boost output

First question to ask is, "Can our old rolls be *safely* worked at higher pressures?" Some operators report unfortunate experiences when they tried; failure of rolls damaged other rolls and shut down entire machines. Often the insurance companies will not permit any increase in pressure.

Lukenweld Drier Rolls are predictable, because they are steel plate construction. Designed for pressure work—as much as 350 psi. and over—they are SAFE. Ask your insurance company what they know about Lukenweld Drier Rolls.

Positive removal of condensate and the higher steam velocity obtained with Lukenweld Jacketed Drier Rolls make them better workers at any steam pressure. Reduction of film, dead steam, entrapped air or other noncondensable gases contributes to their high efficiency. Temperatures are more even across roll faces.

Lukenweld Jacketed Drier Rolls are offered in diameters from two feet to over twenty feet. They are described in Bulletin 358. For a copy, write Lukenweld, Division of Lukens Steel Company, 501 Lukens Bldg., Coatesville, Pa.

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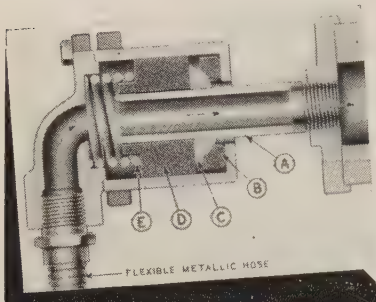
In one sense, in its ability to pay its own way, the Johnson Joint has always been self-supporting. Its packless, self-lubricating, self-adjusting design slashes maintenance costs, boosts operating efficiency. Now, to crown all these virtues comes the new Type S, which needs no external supports. It's the final answer for those tough jobs such as calender service . . . shifts as the roll shifts to end completely the life-shortening wear that rides along with misalignment.



Nipple (A) is fastened to roll or drum. Carbon-graphite ring (B) effects seal against rotating collar (C). Guide (D) supports joint, is also of self-lubricating carbon-graphite. Spring (E) is for initial seating only; in operation joint is pressure-sealed.

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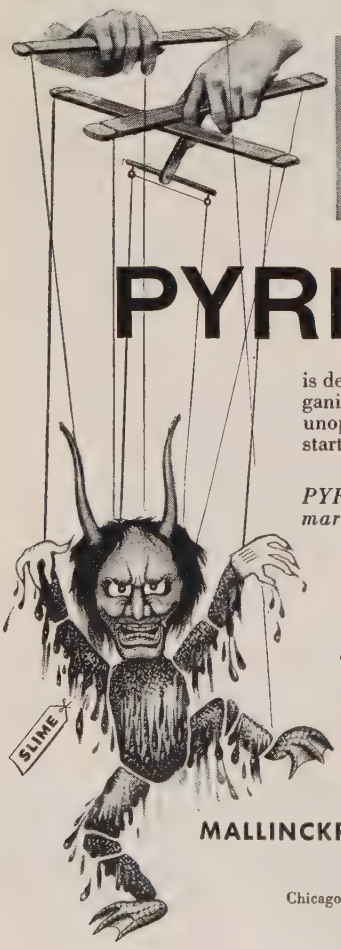

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(continued from page 48 A)

Allied Paper Mills, Hawthorne Paper Co., Kalamazoo Paper Co., Rex Paper Co., St. Regis Paper Co., Sutherland Paper Co., and the Time-Life printing plant, all in Kalamazoo; Central Paper Co., Muskegon; Mac Sim Bar Paper Co., Otsego; Kalamazoo Vegetable Parchment Co., Parchment; Michigan Paper Co. of Plainwell, Plainwell; and the Lee Paper Co., Vicksburg, Michigan.

The success of the Coating Conference, to which all who attended the meeting attested, was due to the officers and members of the Kalamazoo Valley Section of TAPPI and the companies that they represented. The responsibility for arrangements was carried by P. W. Bartholomew, Hawthorne Paper Co., General Chairman; W. A. Kirkpatrick, Allied Paper Mills, Chairman, Technical Papers; and by S. I. Kukolich, Lee Paper Co., Vice-Chairman, James J. Harrison, Michigan Carton Co., Secretary, and Victor Burstein, Michigan Paper Co., Treasurer, of the Kalamazoo Valley Section.

Munitions Board Subcommittee

The National Military Establishment Munitions Board has appointed the following to constitute the Packaging Advisory Group: H. R. Gill, Textile Manufacturers Assoc.; F. P. Hankerson, Associated Cooperage Industries; C. D. Hudson, National Wooden Box Assoc.; L. B. Kiplinger, Steel Shipping Containers Inst.; A. W. Luhrs, Fibre Box Assoc.; R. G. Macdonald, Technical Assoc. Pulp and Paper Industry; Frank Pocta, Paper Shipping Sack Mfgrs. Assoc.; and H. F. White, Can Manufacturers Inst.

EMPLOYMENT SERVICE

In the April and May issues of *Tappi* there were listings of individuals seeking employment and of companies looking for new employees.

This service is performed without charge to either party. It should be kept in mind by all who use this service that no insertion will be repeated except by request made before the 10th of each month.

The response to the ads placed in the previous two issues was considerable. Some of these should have been repeated in this issue but no requests were made. They can be repeated in the July issue if the need still exists and requests are made.

Positions Wanted

E22-49 Superintendent or asst. superintendent, 37, family B.S. chemical engineer. Thirteen years experience, principally in kraft pulping and bleaching, including both technical and operating supervision.

E23-49 Patent Attorney, Registered to practice before the Patent Office. Graduate Ph.D. Chemist. Experienced in pulp and paper making, petroleum, plastics, and inorganic chemicals. Member New York and Federal Courts.

E24-49 Pulp and Paper Technologist, 29, B.S. and 2 years postgraduate work at N. Y. State Coll. Forestry. Two years extensive manufacturing experience in pulp and paper mill. Desires position as assistant superintendent, night superintendent, or chief chemist in fourdrinier mill.

E25-49 Executive assistant, 40, college graduate, 15 years technical supervisory experience in paper manufacture and converting and printing research. Now employed. Experienced in statistical analysis, control, and management assistance.

Positions Open

P8-49 Technically trained man to sell papers for a forward-looking paper house catering mainly to the industrial field. Problems involve engineering, coatings, softness, absorbency, impregnation, etc.

P9-49 Technical men for new research and development laboratory. Well established paper converting company in Ohio catering to the packaging field. Laboratory serves company having several plants in middle and south west.

Jones PULP MASTER*

MORE PERFORMANCE

MORE SPEED

PULPING AND REFINING

TWO-STAGE ACTION

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See it Now in action on your stock

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Builders of Quality Machinery for Paper Mills

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LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Empire State

Syracuse-Oswego Group

Fred. G. Sommerville of the Armstrong Cork Co., Fulton, N. Y., was elected Chairman of the recently reorganized Syracuse-Oswego Group.

On April 11 Professor Borje Steenberg, Director of Research on Paper Technology, Swedish Forest Products Laboratories, Stockholm, Sweden, talked to 75 members and students of the N. Y. State College of Forestry at Syracuse on "The Influence of Paper Machine Variables on Paper Characteristics" and on May 2 the Group heard a talk by Professor Erik Hagglund of the Swedish Forest Products Laboratories.

Northern New York Group

Elmer A. Godfrey, Superintendent, Dexter Sulphite Pulp & Paper Co., Dexter, N. Y. (center), elected April 14 for third term as Chairman, Northern New York Group, Empire State Section, discussing plans with John H. Treadwell, Treadwell Supply Co., Watertown, N. Y. (right), and Homer M. Rice, du Pont Co., Organic Chemical Department, Watertown, N. Y., member Empire State Executive Committee

Elmer A. Godfrey was recently elected for the third term to be *Chairman* of the Northern New York Group which usually meets in or near Watertown, N. Y. Harold Spector of the Taggart Corp., Watertown, N. Y., was elected *Vice-Chairman* and John H. Treadwell of the Treadwell Supply Co., Watertown, N. Y., was again elected *Secretary-Treasurer*. At this meeting, which was attended by about 70, Frank Good of the Magnus Chemical Co., Garwood, N. J., talked on "Pulp and Paper Mill Cleaning." On May 12 the program was devoted to an entertainment sponsored by the supplier members. R. G. Macdonald, Secretary of TAPPI was present and made a few remarks.

Sulphite Mill Control

On March 10 R. M. Drummond, Chief Chemist, Research Division, International Paper Co., Glens Falls, N. Y., gave a talk on "Sulphite Mill Control." Mr. Drummond's remarks follow:

"Mr. Chairman, members of the Northern New York Group of the TAPPI Empire State Section and guests: Mr. Godfrey asked me to speak to you tonight on mill control.

"Mill control is a very large subject and is one on which much has been spoken and written. A number of subjects come under this heading, such as the actual tests used in the evaluating of the raw materials employed in the manufacturing process; second, the actual control of the manufacturing process itself; and third, the duties of the technical superintendent and technical personnel in a paper mill, including, as is expected in some mills, research and development. All are correlated and I would not attempt to cover them all tonight; rather, I desire to give you a brief outline on the control tests which can be made on a daily routine basis as an aid in maintaining the quality of the finished paper. This, I do to give those present, not wholly familiar with the manufacturing process of paper, some idea of what control is generally practiced in most mills. Let it be understood that no two mills will be exactly the same as the requirements depend—first, on the raw materials used and second, on the finished product.

"In courtesy to your Chairman, I have chosen a sulphite mill as the basis of my outline.

"Wood is our basic raw material and segregation into different species, e.g., spruce, fir, and pine; also for hardwoods, if any are used, is essential. A check of the quality of the wood purchased as to age, density, moisture, and soundness is a must if you wish to know your yields, your costs, and control the quality of your product. How you start, which is your wood, definitely effects how you will finish—in other words, your finished paper. The question of wood storage is also in this picture and I think it is now the consensus that all wood should be barked to prevent the loss of unbarked wood in storage.

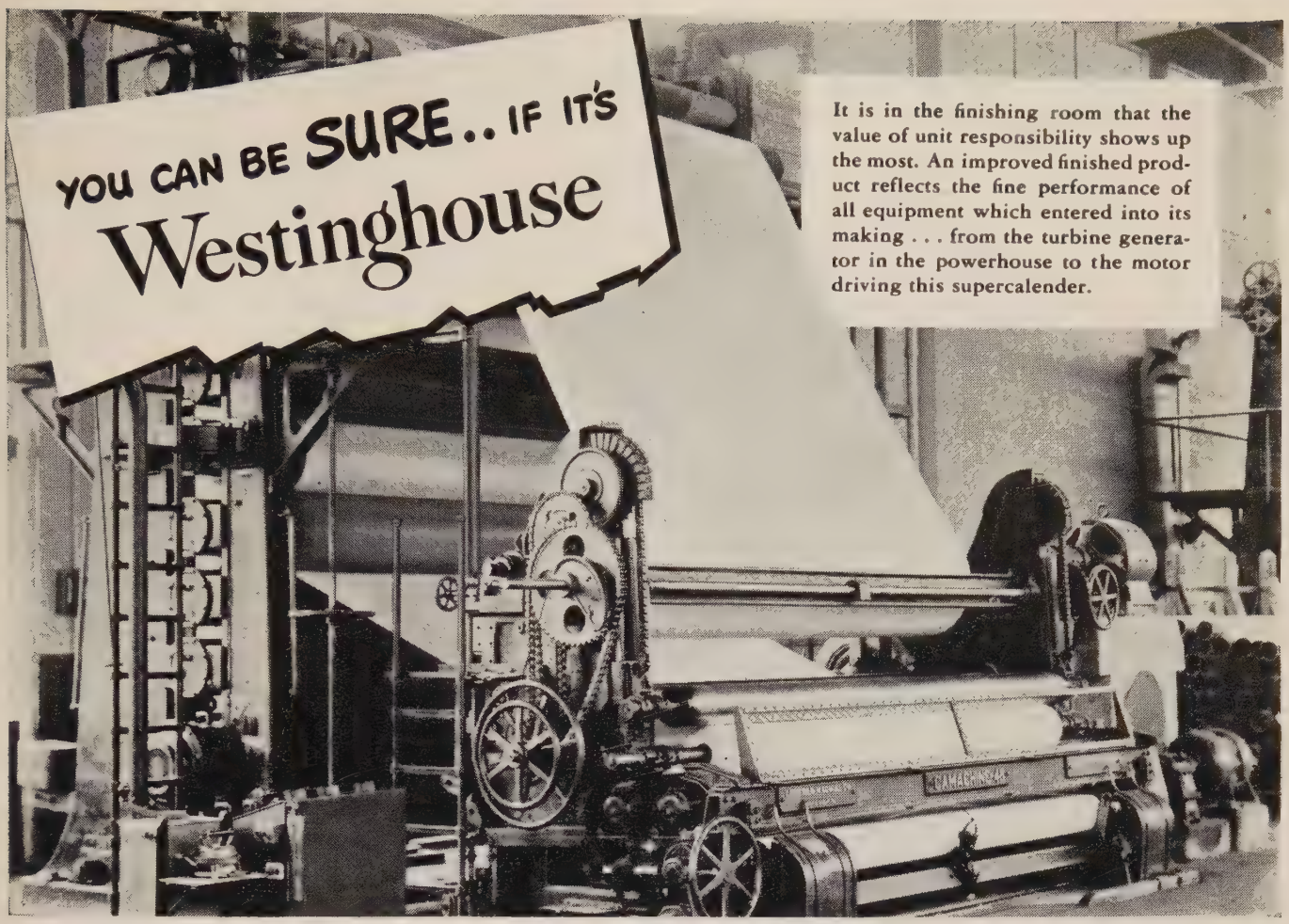
"The wood is next washed, barked and cleaned with whatever equipment is available. If clean pulp is desired, some wood must be hand cleaned for rot, knots, broomed ends, sunburn, etc., because the major portion of the obnoxious dirt found in bleached pulps and papers is wood dirt. Next come the chippers where regular inspection of chipper knives—the use of no short butts to prevent slabbing and giving too much waste to the crushers—will aid in the production of uniform sized chips with the minimum of waste.

"The use of weightometer, automatic chip sampler, along with screenage tests on the chips for control of size, dirt, etc., are desired. Chip waste and sawdust should be measured daily.

"Moisture tests on chips for the control of the ratio of wood to acid in the cooking should be made.

"Preparation of the cooking acid requires a check on the sulphur dioxide content of the sulphur burner gas, preferably with a continuous recorder. Testing of the acid for combined and total SO_2 is required, as well as the testing of the cooking liquor for per cent SO_2 and color during the cooking process. The sense of smell and his judgment of color of the sulphite cook are probably the two controls still most widely used as an indication as to when the digester is ready to blow and I would not rob the cook of this skill and art for worlds. He can be aided in his judgment, however, of color at least by the use of some type of electro-photometer using a photoelectric cell.

(continued on page 54A)



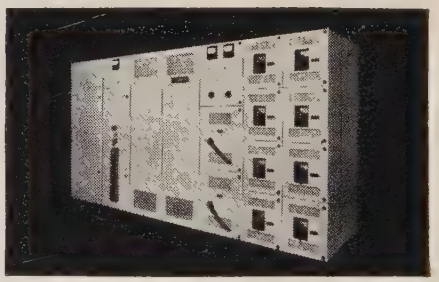
It is in the finishing room that the value of unit responsibility shows up the most. An improved finished product reflects the fine performance of all equipment which entered into its making . . . from the turbine generator in the powerhouse to the motor driving this supercalender.

Putting power to work productively can be a major problem—or a simple one. Obtaining items from many sources means chances for costly errors and delays.

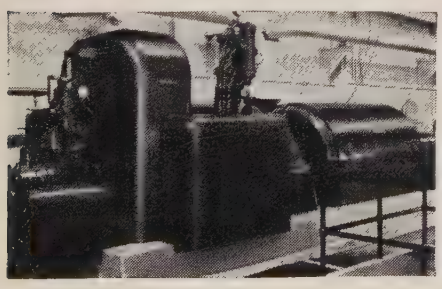
Westinghouse offers the way to simplify the job. From equipment for generation of electrical or steam power, to the most specialized types of drives and control for its utilization, Westinghouse provides a single source of supply, competent to take responsibility for performance of all parts of the job.

Here are a few of the places where Westinghouse unit responsibility prevents headaches . . . saves money . . . assures more productive power. For details, call your local Westinghouse office or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

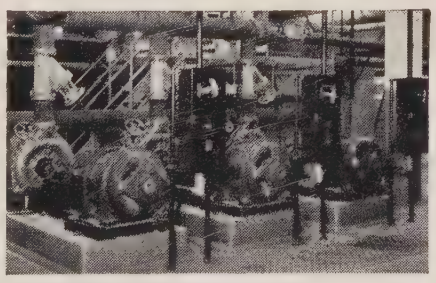
J-94775



SWITCHGEAR—Westinghouse supplies a complete range of "Unitized" metal-clad switchgear that permits quick, economical installation.



TURBINES—Constant process steam pressure and constant speed are maintained by this modern, 3,000-kw, double-bleeder turbine, a unit of the Westinghouse complete line.



AUXILIARIES—Boiler room auxiliaries driven by Westinghouse motors and control assure continuity of service and give the desired flexibility of operation.

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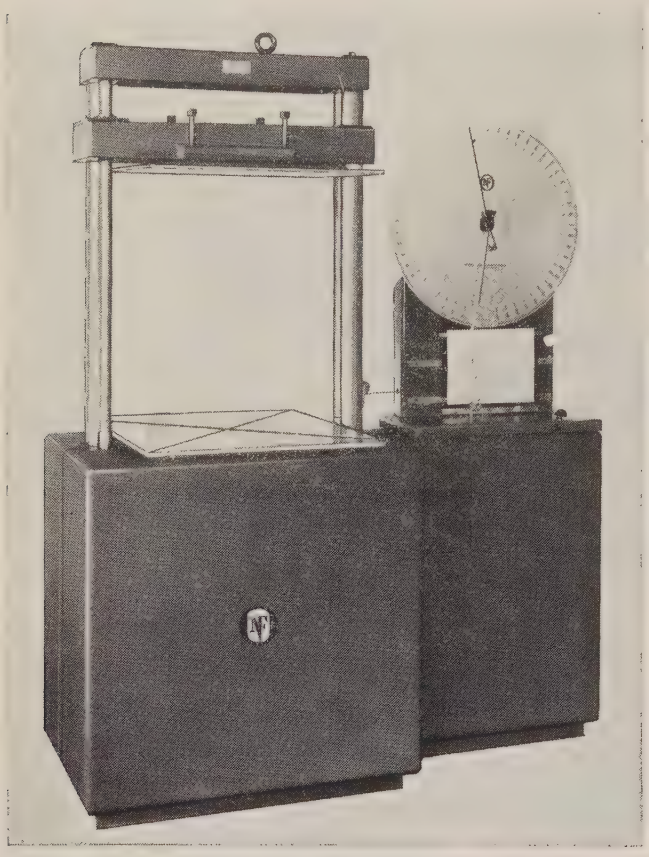

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(continued from page 52 A)

"Washing of pulp to a definite pH value of wash water from the blow pits is usually found helpful.

"Yield of pulp is determined from wood or chip density tests, weightometer readings, and moisture determination on chips to give the actual wood cooked per digester. This is then compared with pulp obtained from data from such measuring devices as Sparling meters, Flowrators, Venturi flumes, or by lapping or drying the pulp.

"Quality of Pulp—Hardness of pulp determined by permanganate, Roe chlorine numbers or bleach consumption tests. Per cent rejections form laboratory tailings test on each digester and metering of total rejections from sulphite mill. Rejections are controlled by regular screen consistencies, inspection of screen plates, etc. Initial strength tests on pulp from each cook. Standard TAPPI beater tests on each car of pulp shipped or on several cooks per day.

"Machine Furnish—Pulp, filler, size, color, alum, etc., accuratiely weighed or metered into beaters. If slush pulp is used, proportioning is controlled by consistency regulators, metering gates, etc. In connecting with proportioning and metering the recent installations in Canadian mills of Fischer & Porter Flowrator proportioning systems are worthy of study. In connection with machine furnish, a definite beating or mixing cycle is used, depending on the grade of paper being made.

"Machine Operating Conditions—Stock is regulated to machine by a consistency regulator and white water is added in a constant volume. Consistency tests made on head box stock to determine uniformity of stock going to the slice. Automatic temperature control also used on head box stock and recording liquid level gages to aid in maintaining the correct head and temperature behind slice for a certain wire speed and furnish.

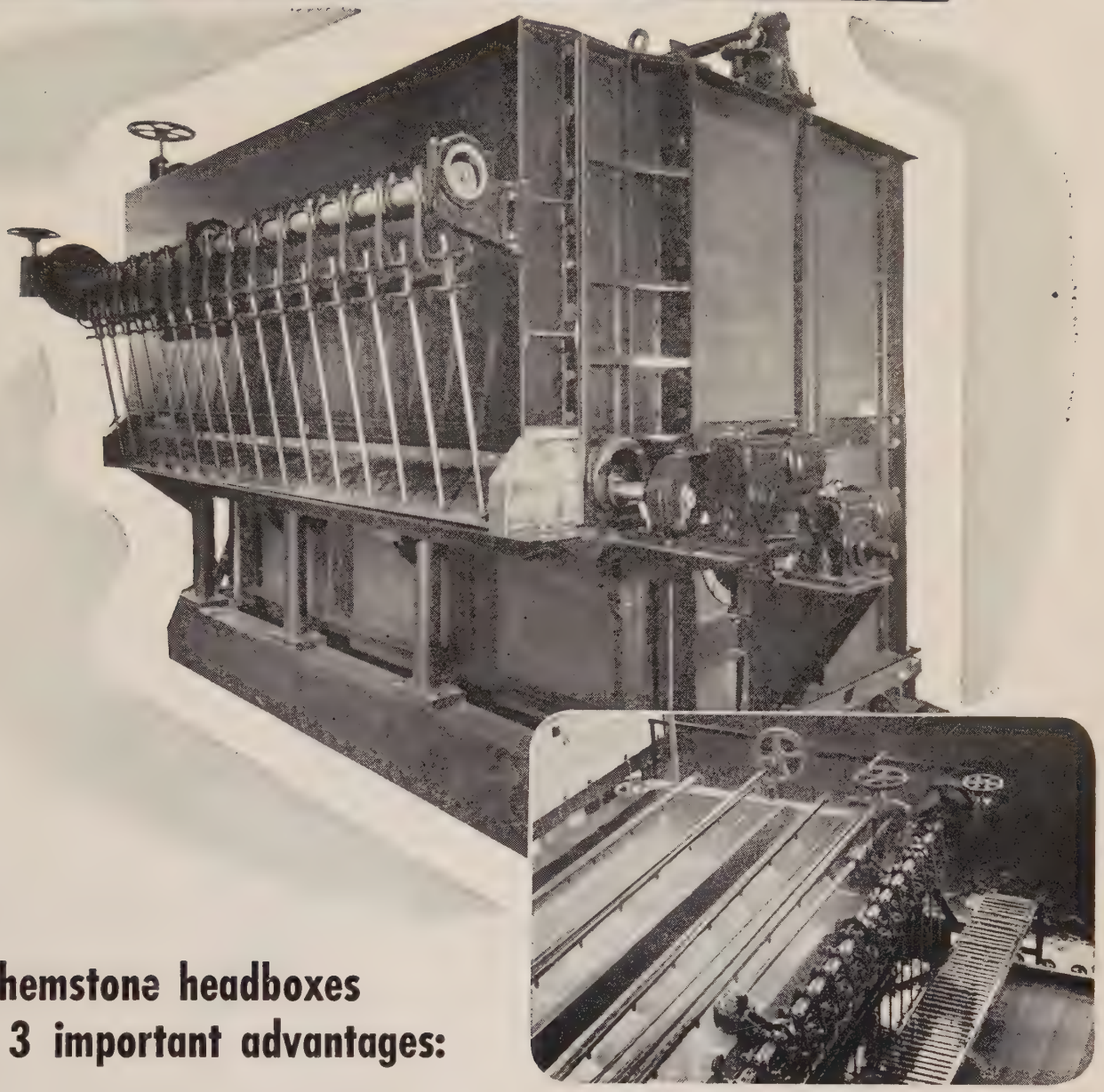
"Verigraph or similar types of moisture controllers can be used to maintain uniform moisture in the finished sheet. Basis weight determinations made on at least seven points across each reel to maintain uniform weight on machine. Recording calipers are also used at times to maintain uniform sheet thickness.

"Finished paper—The following tests are usually carried out on an offset sheet of paper for the maintenance of quality: basis weight, caliper, smoothness, mullen, tear, porosity, pick, fuzz, ink penetration (both R.D. and K&N), brightness, formation, ash, and moisture (in terms of relative humidity in skids of paper with a sword hygrometer).

"No doubt you are amazed at the number of tests I have suggested in this outline and probably are saying that many of them are not needed. I do not say that all are necessary and I do not know of any mill which does them all, but I do know of some mills in which most of these control tests are part of the manufacturing process. Long as this list may seem, there is more which should be done, especially if good process control is desired. Each mill should have a good analytical laboratory or, at least, one good analyst in the control department. His duties, although involved with control, are not so much directly connected with the manufacturing process as with the raw materials. The raw materials are many and are basically important to quality and good operation. I have already mentioned wood as being of fundamental importance and I should say the next raw material in importance is water. Most mills use 30–40,000 U. S. gallons of water per ton of paper made and, if this requires treatment and filtration, frequent checks are necessary. Boiler feed waters also usually require treatment and control. In connection with steam plant operation, if a mill generates its own steam, coal is an important item, requiring analysis for ash and B.t.u., especially as most coals are purchased on this basis.

(continued on page 56 A)

Dimensionally stable...Clean...Chemically resistant



...Chemstone headboxes have 3 important advantages:

MADE of asbestos and cement, and integrally waterproofed, Chemstone is helping paper mill men solve the problem of headboxes, consistency regulator boxes, flow boxes, linings for wire and couch pits, and stock chests because:

1. It won't shrink or swell—Chemstone is a tough, monolithic material molded under high pressure. It has unusual dimensional stability due to its low water absorption factor. When used for headboxes and other purposes in mills, it is light but strong, provides an attractively finished job that lasts indefinitely.

2. It resists slime and bacteria—Chemstone boxes prove unusually resistant to bacteria and other surface accumulations. Chemstone stays clean for long periods, but when cleaning is necessary, it can be washed easily and quickly by a simple hosing operation.

Chemstone headbox *on Fourdrinier machine making Kraft wrapping from northern Kraft pulp.*

3. It resists chemical action—Chemstone possesses the ability of asbestos and cement products to resist chemical action. Equipment made of Chemstone is free from metallic oxides, resists both mild alkalis and acids, and is unaffected by most mill waters. For full details, write, for data sheet DS series 405, to Johns-Manville, Box 290, New York 16, N. Y.

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Pennsalt Hydrogen Peroxide for Bleaching Groundwood

More and more paper manufacturers are showing interest in the use of Pennsalt Hydrogen Peroxide for bleaching groundwood. This interest is based on savings in production costs, increased yields from available wood, and superior qualities in specific grades of paper. With proper bleaching, it is possible to obtain maximum brightness and permit use of larger proportions of groundwood.

Bleached Groundwood has these distinct advantages:

- **Low cost—most of wood entering groundwood process is recoverable.**
- **No serious waste liquor disposal problem.**
- **Desirable printing properties—cushion, flexibility, ink affinity, high opacity per ream weight, ability to take coating and colors.**
- **Popular application in items of transitory usage—such as magazine, catalog, directory, mimeograph, tablet, tissue, toweling, book and hanging papers.**

An experienced Pennsalt representative can show you how to use Hydrogen Peroxide to advantage in your bleaching operation. Write: Heavy Chemicals Division, Pennsylvania Salt Manufacturing Company, Philadelphia 7, Pa.

PENN SALT
chemicals

(continued from page 54 A)

"In addition to these major materials, the average mill uses dyestuffs, rosin, clay, starch, special fillers, and a miscellaneous number of other items, the quality of which require checking at least occasionally. There is also the question of slime control, corrosion, felt washing, etc., in which a good analyst can be of great service. There are also those times which we all know so well when the mill superintendent bursts into the laboratory with a handful of stuff which looks like floor sweepings and says "I got that on the third press—where the H--- is it coming from?" In a spot like this, where an answer is wanted immediately, we usually guess and later hope with good analysis that the true source of the trouble may be found.

"Customer complaints also eventually fall into the lap of the control department, after coming down the line through the sales department and management. Here, once again, the technical personnel are supposed to know all the answers. Often such answers can be found by good analysis.

"To date, I have dealt with a mill producing its own pulp but there are many mills which are really convertors, purchasing all their pulp as well as the other necessary raw materials. In such mills the control laboratory must be able to determine the fitness of a pulp for the production of the paper made in that mill. The quality of a pulp is mainly based on past experience, usually recorded in the records of an efficient technical department. Such requirements as cleanliness, strength development for mullen and tear, and beating time should be evaluated before a pulp is either purchased or put into production. All pulps are purchased on an air-dry basis, so frequent moisture checks on incoming shipments are essential. This is the starting point for all costs in a mill which buys its pulp.

"In the economics of mill production, the control department is definitely a factor, as usually they are responsible for the measurement of all mill wastes. Stock balances must be figured and per cent furnish data published each month. What goes into the process, what comes out as tons of paper made, and what is wasted must balance for good economics. It is here that a good control department can really pay its way by the keeping of good statistical records on raw materials and wastes. It is not only their duty to keep accurate records of wastes but also to keep them to a minimum, as well as devising ways and means of decreasing them. Waste measurement and sampling is something which requires added attention and study in many mills. Normally, sewers are either too small or inaccessible but good waste measurement can pay dividends and, if possible, have all wastes leave the mill at one point where an adequate weir with automatic sampling can be installed. In connection with sampling, I hear good reports of the De Zurick liquid sampler. In one of our mills we have had one in satisfactory operation several months. This sampler, it is claimed, takes a sample in proportion to the flow of liquid in the channel and checking seems to bear this out.

"What I have outlined to date seems like a large order for any department or for any technical superintendent, paper mill chemist or whatever title the head of such a department may be called. Many things are expected of a paper mill technologist and among these are that he should know all the answers. He has to be a rough and ready character, at least ready for any emergency, if not necessarily rough. I once knew a technical superintendent who was told by the mill manager that he was as good as they come as regards his work and new ideas but that he was just not tough enough—he was too polite for a paper mill. This may sound like an exaggeration but a good mill chemist is definitely in the center of the production battle and not merely behind the lines. It is not enough that he run his department efficiently but he should also keep abreast of the times as well as contribute toward improvements and economies in his mill's operation. The technical

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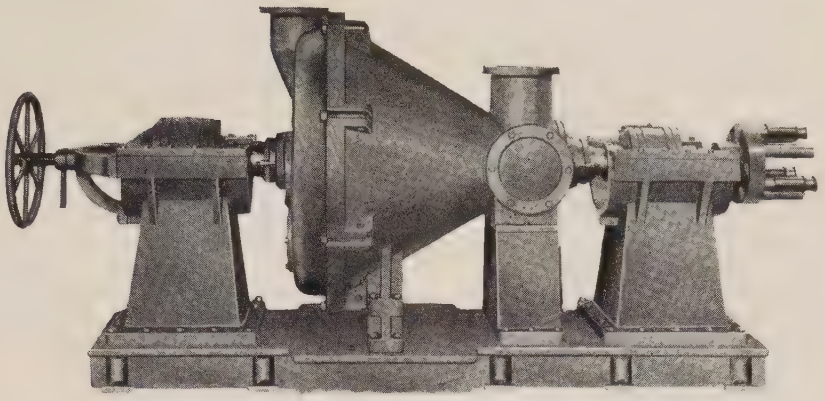
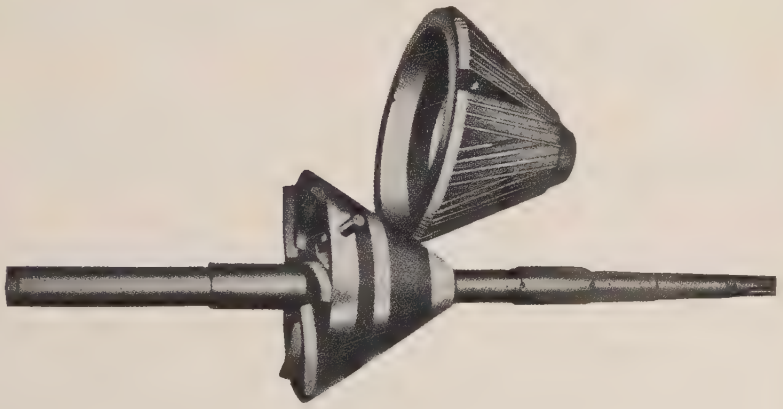


IN FOUR SIZES

Number 0 for experimental and test purposes. Numbers 1, 2 and 3 for production.



Auxiliary Plug mounted securely on shaft ready to receive Quick Change Plug Liners: Cast Steel and Alloy Iron with $\frac{3}{8}''$ and $\frac{1}{2}''$ wide bars. Regular Liners with $\frac{3}{16}''$, $\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{1}{2}''$ and $\frac{3}{4}''$ wide bars.

Hermann Sectional type shell filling for maximum brushing and hydration. Also, one-piece cast steel shell liners with $\frac{3}{8}''$ and $\frac{1}{2}''$ wide bars.

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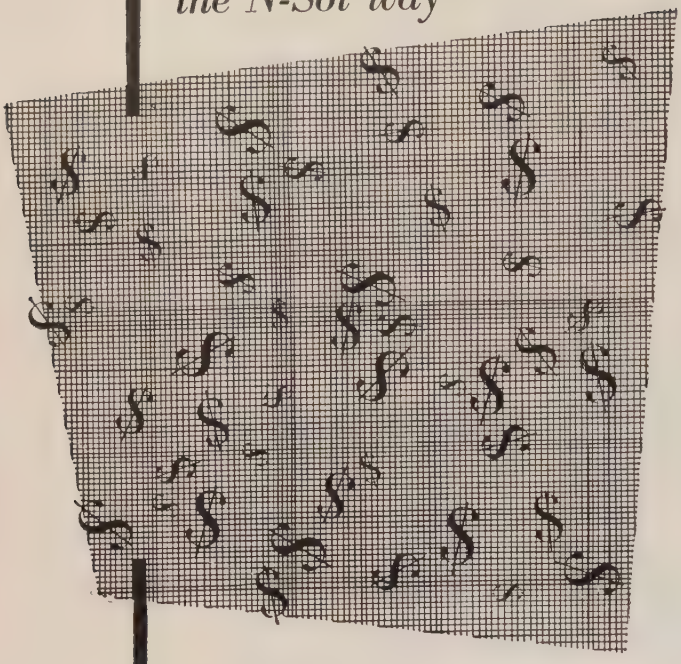
the N-Sol way



more fibre
on the wire

Increased fibre and filler held in the wet web formation reduces losses in the white water. Solids content of the white water coming from the machine when N-Sol has been used may be cut by approximately 50%.

You see the difference when you add N-Sol (activated silica sol) on the machine side of the jordans. There's an increase in weight of the sheet and a reduction in the two-sidedness of the sheet.

N-Sol is economical, too. Made conveniently in your mill by reacting "N" Silicate of Soda with a suitable reagent. The cost is slightly better than half that of ordinary glue.

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N-Sol Processes are licensed without charge. Full directions and samples of "N" Silicate on request.

PQ Silicates of Soda

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Utica, Ill.

(continued from page 56 A)

superintendent in many mills is apt to be overloaded but his situation as regards help, I am sure, has improved in recent years. I remember in the lean years of the paper industry (1930–36) when if one of your staff left, it was considered an economy and one had merely to carry on with one less. It is better now.

"This brings me to the point as to why is efficient control needed. Our system of free enterprise and competition requires that each mill must strive to produce more and better paper at lower costs. Papermaking is essentially still an art and, unfortunately for the industry in the last few years, operators sufficiently skilled in this art have been practically impossible to obtain. It may be our technical methods which have robbed the operators of some of their skill but now these methods should be a guide to them in indicating trouble ahead so that it can be avoided. Control work should not be looked upon as a check on the operators but as an aid to them in the development of their skill toward the production of a product of maximum uniformity.

"Mill control costs money and I know mills where the cost is $2.00 per ton of product which, on a production of 200 tons per day, is an item worthy of consideration. Perhaps it is my Scottish blood but I wonder at times if we are getting true value for such an expenditure. I installed mill control systems in mills 10 to 15 years ago and, essentially, they are the same today as then. Perhaps something has been added but little has probably been taken away. We all have a tendency to add tests but seldom to discontinue them. Despite the fact that we may have a statistical record of a test for years, it can outlive its usefulness, and has, if the operators no longer use it. All heads of departments should sit down at least every six months and review the services rendered to each of them by the control department, cutting out the deadwood and including tests current to the operation.

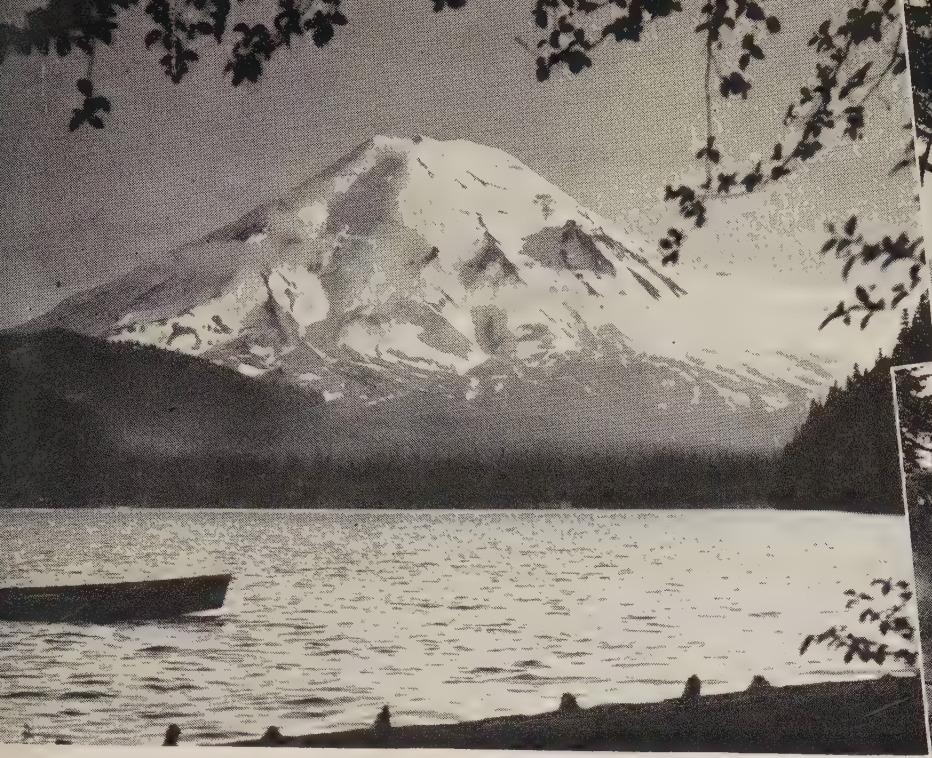
"Surely we have advanced in the last 10 or 15 years in control methods so I think it is time for management, as well as the technical personnel to give some thought as to how our mill control systems can be made to serve us better at lower or at least the same cost.

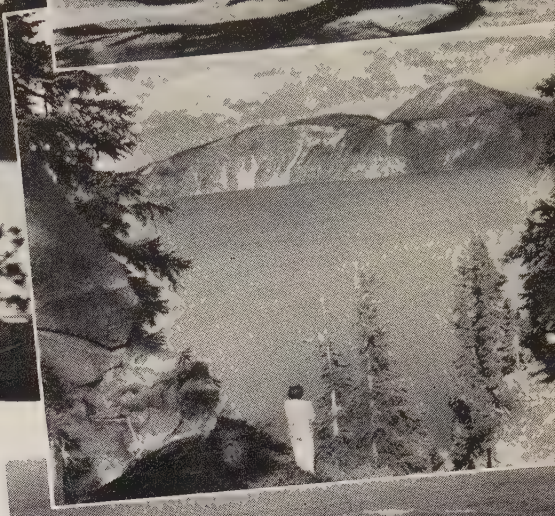
"One way I am sure this can be done is by more instrumentation in our mills. Labor or wages is the main cost of mill control and this can be cut by the use of automatic recorders. I have great faith in recorders, provided they are kept in good repair and this calls for the services of a good instrument man. Every mill should have such a service man, factory trained, which any instrument company will be glad to do for you. A recorder is an automatic foreman who is on the job 24-hours a day. I mentioned before, as part of my outline on machine operation, the control of head box levels and temperatures by means of recorders. I know operators who balked somewhat at their installation but now could not operate without them. If you run a closed white water system in your mill, merely install one or two temperature recorders strategically throughout it and you will have no trouble telling when, where, or who left that fresh water valve open, which is effecting head box temperatures.

"For efficient operation, good consistency regulation is an essential and with such regulators as the Trimbey, a recorder showing the valve stem travel, is a must. Many times, regulators run with the water valve either closed or shut, most of the day. Such a regulator is useless because, for a Trimbey regulator to be functioning, the valve should be hunting in a narrow range all the time. A recorder shows these variations to be too great for the regulator to take care of efficiently.

"Automatic systems appeal to me greatly and I think that they are worth while, from a dollar standpoint. I know a three-machine mill which, at one time, had seven men per shift in the beater room, that now runs with only

(continued on page 60 A)





ABOVE—Spirit Lake, about 50 miles from Portland, lies at the foot of snow-covered Mt. St. Helens in Southwest Washington. The mountain rears its head over territory that includes the finest stand of evergreen trees in the state.

PACK UP YOUR TROUBLES in an old kit bag . . . . . AND LEAVE 'EM HOME

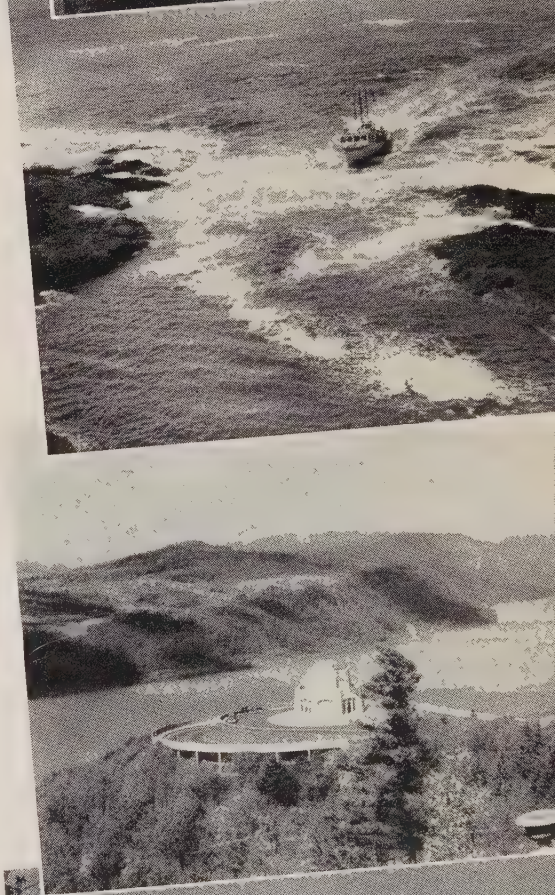
but bring yourself to the fall convention of TAPPI to be held at the Multnomah Hotel in Portland, Ore., September 12–15.

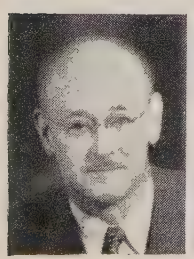
When you step on that train September 8th westbound for Portland, you'll be heading for the autumn wonderland of the Pacific Northwest.

Later on we'll tell you about the meaty instructive four-day program, but this time let's talk about the good times you will have both at the convention and on private side trips. In addition to the regular business, there will be teas, bridge luncheons, golf, bowling, a trip to Mt. Hood, cocktail hours, dancing, a fashion show—and the grand banquet with a gala floor show and no speeches.

Following the meeting you can visit the ocean beaches of Oregon and Washington, hunt, go fishing for salmon on the Columbia or for trout in the mountains, play golf or go on up and down the Pacific coast to visit the mills.

Better hang a "Gone Indefinitely" sign on your desk back home, because you'll have a hard time leaving the Pacific Northwest playground.





AT RIGHT, top to bottom—This wind-gnarled tree weaves a graceful pattern against a flaming sunset sky near Arch Cape at Cannon Beach on the coast of Oregon.—Crater Lake in Oregon.—Bringing in your own salmon through the narrow harbor at Depoe Bay, Oregon.—Looking down on Oregon's Vista House, a scenic stop-off along the Columbia River Highway about 25 miles from Portland, and across the river to the forests of the Washington side.—Mount Hood overshadows one of Hood River's world-famous orchards, about 50 miles from Portland. Massive Timberline Lodge on the mountain offers skiing, dining and relaxing.—**AT LEFT**—Ray Smythe.

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PAPER-AIDS

improve sheet formation—giving usual benefits without the disadvantages

One outstanding point regarding use of Dicalite paper-aids is that they produce a definite (often remarkable) improvement in sheet formation—WITHOUT INCREASING DENSITY and WITHOUT CAUSING SLOWER DRAINAGE. This one point alone has made Dicalite a valued material in many paper mills, because it can increase production, improve uniform quality and reduce operating costs.

Dicalite improves formation—not by chemical means because it is inert—but by physical action of causing a more thorough and uniform dispersion of fibers at the wet end during formation. This action is peculiar to diatomaceous earth, due to the structure of the particles. We will be glad to mail you full information or send a representative on request.

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DICALITE

PAPER-AIDS FOR BETTER PAPER PRODUCTS

(continued from page 58 A)

three men between the grinder room and the machines, and one of these runs the sodium peroxide bleach plant which has been added recently. Automatic systems, however, need good servicing, so I stress again the need of a good instrument man. This reminds me of a story I heard on the radio the other day. Seemingly, the publisher of one of the popular magazines installed an automatic machine which picked out your name plate when your subscription ran out and sent you a letter all sealed, addressed, and stamped before leaving the machine. He was so proud of this machine that he wrote an editorial about it and then something went wrong. Farmer Jones in Nebraska received 11,600 letters asking him to renew his subscription and, after opening 200, he said I give up and sent them $6.00.

"Instrumentation has advanced greatly in process control in recent years but little has been accomplished in the testing field. We still need a good automatic freeness recorder, as well as an accurate consistency recorder and regulators for low consistencies such as at the head box. It is up to the technical personnel to develop such instruments as well as others such as the automatic physical testing of the finished paper.

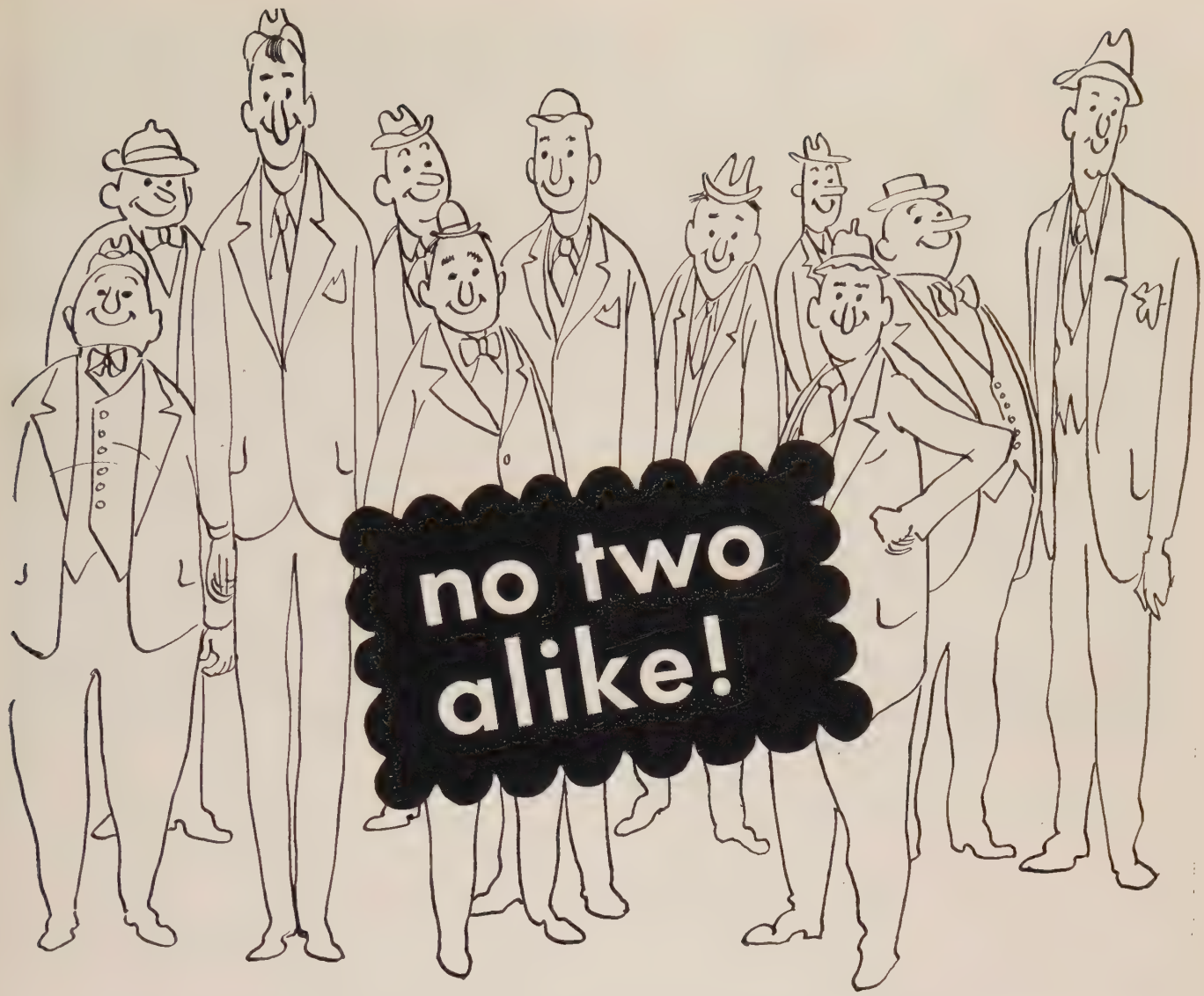
"The location of testing stations is also a point worthy of consideration as many mills use what are known as sample runners. These can be eliminated by locating your testing stations right at the end of your paper machines. This system I tend to favor as the operators are in constant touch with physical properties of the finished paper and, if specifications are not being met, there is no delay in changes being made. Some mills prefer one central laboratory equipped with temperature and humidity control to which all samples are brought. One mill, I am told, has installed pneumatic pipes to bring samples from each machine to such a central laboratory and so eliminate their runners in this way.

"In these days of high-speed presses, air conditioned press rooms, and converting operations requiring great precision and uniformity in the paper, a constant humidity room for testing purposes is definitely required. Do not think for a moment that I suggest testing all paper samples under standard conditions of humidity and temperature, as such is too slow and wholly impractical but a portion of all paper shipped should be checked under standard conditions.

"Talking of finished paper makes me think of customer specifications and reminds me of a true incident. A newsprint mill located near a large city supplied paper to one of the local papers in that city. There were two main daily newspapers in the city, one of them using the paper of the mill I knew. A reporter was out speaking to the mill staff one day and he stated their paper was by far the best and that his wife would not let him buy the other paper as theirs was so much better to wrap the garbage in. I often wonder when we make paper to certain specifications for a supposedly specific purpose, if it would not, at times, be better to wrap the garbage in. What I am trying to say is—I do not think we know enough of the requirements of our customers. We practically submit all finished paper for all customers to the same physical tests and many times, no doubt, strive to meet specifications which have no relation to its use. I think here is a place where savings can be made, if our own technical help in cooperation with the customer would study the properties of the finished paper in relationship to its end use. We still do not know in many cases and neither does our customer—what is a good sheet of paper.

"We have advanced in the standardization of our testing procedures but we have not gone very far in this respect in our mill control methods. Our standard TAPPI methods

(continued on page 62 A)



No supplier ever built two identical paper machines. Even though the same set of prints is used the machines differ in more ways than one—each has a personality of its own.

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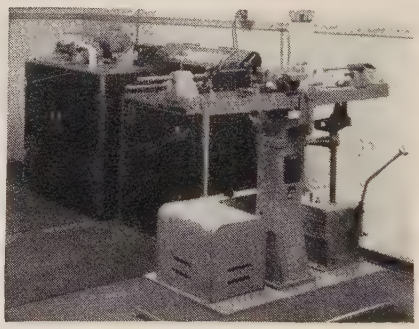

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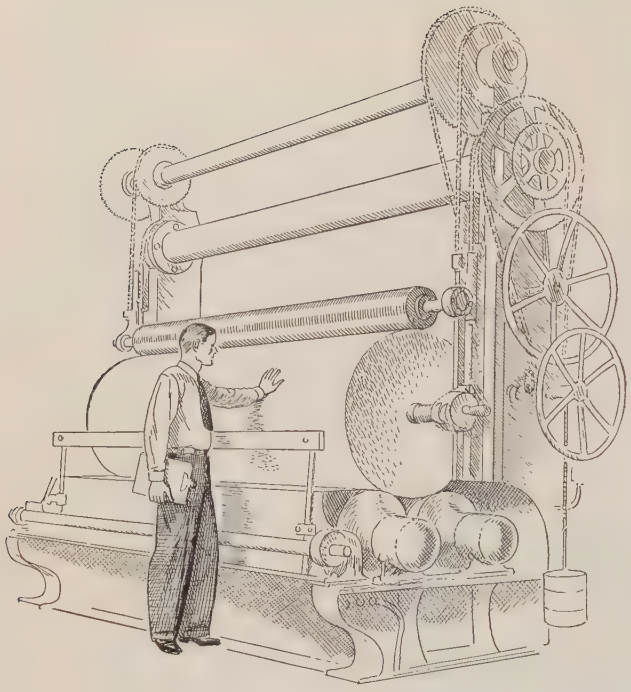

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Butterworth Calender Rolls

(continued from page 60 A)

are good, and please do not think that I underestimate their value for a moment; on the other hand, most of them are too involved and too long to be used as mill routine tests. Despite the fact that we have developed evaluating methods for our raw materials, there is still much work to be done because, in many mills today, there is still more groundwood pulp made by the Blue glass and sulphite by the cook's nose and eye, than there is by any test procedure.

"Another thing we have not done, is standardize our testing instruments. Any instrument maker can produce a piece of testing equipment as he thinks fit—he is not required to build it to standard specifications. This is more than evident if you try to cross check tests between different mills, as normally two pieces of supposedly the same testing equipment just do not check. Take for example the Mullen test, probably the most widely used standard for the evaluation of paper there is in the industry. There is no standard mullen test or, to date, any place where one can send a mullen tester to be standardized. We all have our own standards and yet we make paper for the same customers to, supposedly, the same specifications. This may sound a little ridiculous but it is true because, we, ourselves, check regularly with the mill, the customer, who calls for rather rigid specifications, and a disinterested party such as the Institute of Paper Chemistry. This is a four-way check and the correlation, at times, is not so good.

"Some instruments have been standardized, such as the Canadian standard freeness tester and the General Electric brightness tester. The former, with the aid of standard plates, orifices, etc., a laboratory can keep in standard condition. The brightness tester, as you all know, has a monthly checking system handled by the Institute of Paper Chemistry, but even this instrument should be sent back to the Institute, periodically for recalibration. The story on our other instruments is not so good and that is why we, as technical men in the paper industry, need to do something about the standardization of our testing equipment. The suppliers of our raw materials are becoming more and more aware of this, because we also specify our requirements, and are making efforts along these lines so it is up to us to do our part.

"I hope tonight I have given you some food for thought as to how we can improve our present systems of mill control. If we do this, we shall be better able to meet our customer's requirements with a product which is better and will cost less to manufacture."

Hudson River Group

Charles N. Hagar of the B-F-D Division, Diamond Match Co., Plattsburg, N. Y., recently succeeded R. H. Wiles as Chairman of the Hudson River Group.

On April 21 this group visited the plant of the Sandy Hill Iron and Brass Works at Hudson Falls, N. Y., where a number of interesting exhibits were shown. In the evening the group met at the Village Inn, South Glens Falls and participated in a panel discussion on "Corrosion." Members of the panel included R. S. Burr, Arthur W. Tracy, and B. W. Eerk, American Brass Co., Waterbury, Conn., who discussed "Copper Base Alloys," R. C. Cunningham, Industrial Steels, Inc., Cambridge, Mass., who talked about "Stainless Steel," Alexander T. Baldwin and C. M. Jekot, Lithgow Corp., Norwalk, Conn., on "Phenolic Resins," R. T. Barnes, Jr., International Nickel Co., New York, N. Y., on "Nickel-Base Alloys," and Robert R. Pierce, Pennsylvania Salt Mfg. Co., on "Rubber-Base Plastics." A group from paper companies led the discussion. These included Charles Wright, Stevens & Thompson Paper Co., Greenwich, N. Y., R. E. March, Marinette Paper Co., Inc., Fort Edward, N. Y., and George E. Soyka, Fort Orange Paper Co., Castleton-on-Hudson, N. Y.

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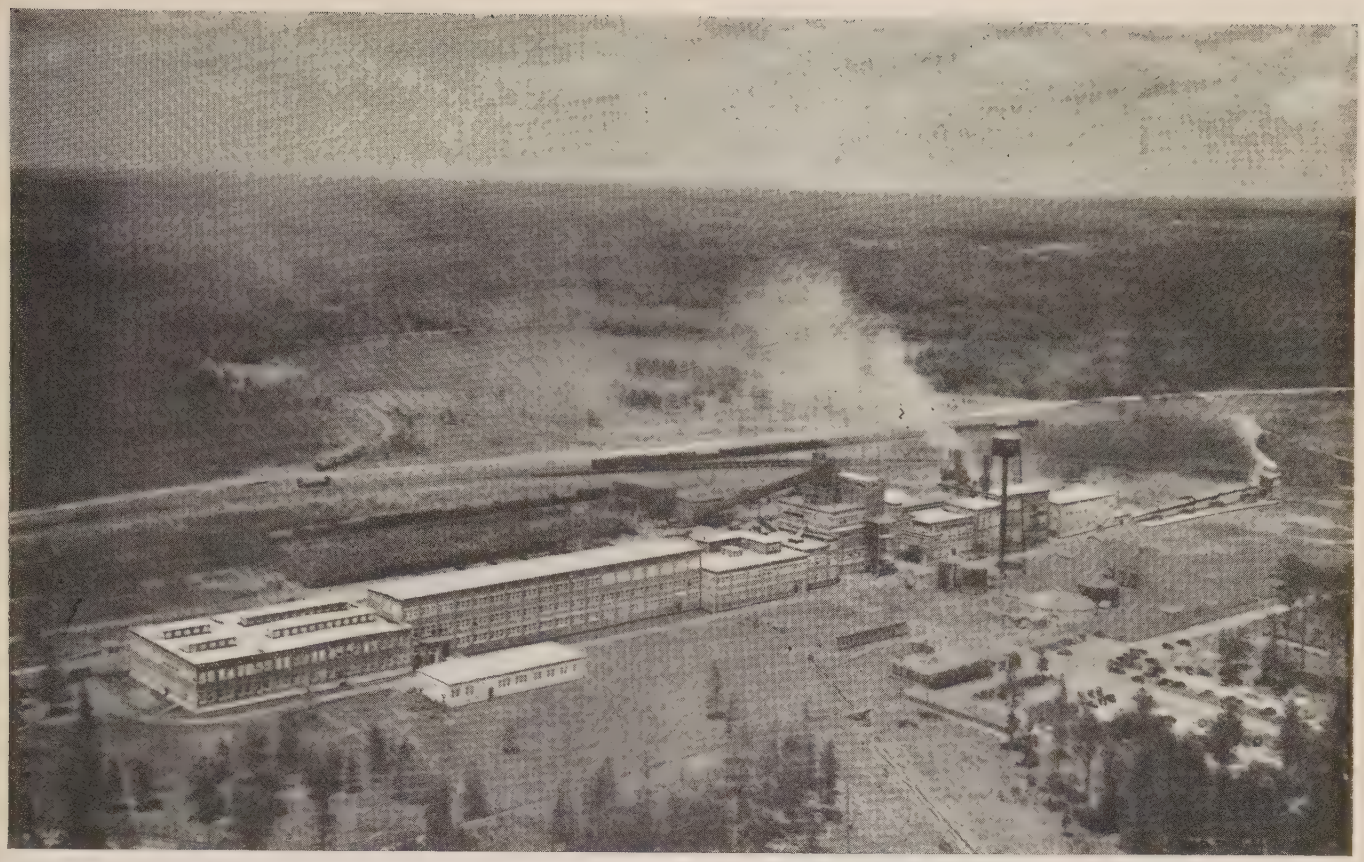

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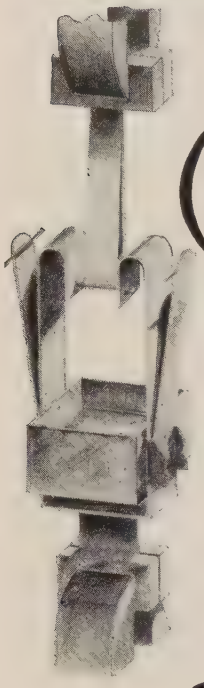

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Standard of the World

(continued from page 62 A)

On May 20 the group met at Plattsburg, N. Y., where visits were made to the mills of the B-F-D Diamond Match Co., and the Imperial Paper and Color Co. In the evening, at the Cumberland Hotel, James T. Coghill of the Curlator Corp., Rochester, N. Y., discussed the new Curlator machine.

Metropolitan Group

The Metropolitan Group met at Fraunces Tavern in New York City on May 9. John B. Calkin, University of Maine, presided as Chairman.

Chairman Calkin announced the appointment of the *Advisory Committee* to serve for the coming year: Harold M. Annis, Oxford Paper Co.; Richard T. Bingham, TAPPI; Sidney A. Grossman, Liberty Corrugated Container Corp.; Ralph W. Kumler, American Cyanamid Co.; N. L. Nourse, Brown Co.; and the *Recording Secretary,* William Landes, Paper & Pulp Testing Laboratories. *Program Committee Chairman:* W. R. Willets, Titanium Pigment Corp.; *Arrangements Committee Chairman:* Jack Butterworth, Socony Vacuum Oil Co.; and *Membership Committee Chairman:* Lewis S. Reid, Metropolitan Life Insurance Co.

Jack Butterworth and Henry Perry were designated to represent the Metropolitan group at the Annual Meeting of the Empire State Section on June 2–4, 1949, at the Hotel Sagamore, Bolton Landing, Lake George, N. Y.

The speaker of the evening was L. R. Blasius of the New York Telephone Co. His topic was "Highways of Communication—Microwaves." His comments follow:

"Sound was first transmitted through space by the telephone, an electrical device invented by Alexander Graham Bell. He conceived the idea of imparting the characteristics of sound waves to an electric current and then causing this current to reproduce the original sound waves. Today, however, sound is transmitted by electromagnetic waves.

"The first electromagnetic waves were discovered in 1662 by Sir Isaac Newton, the great English natural philosopher. He succeeded in splitting sunlight into various colors with a glass prism. These pure colors of light are a form of electromagnetic waves. About 1800, it was discovered that different colors of light had different temperatures. It was also found that other kinds of waves, invisible waves, existed, some of which were longer and some of which were shorter than light waves. The next step in the discovery of electromagnetic waves was the presentation by Maxwell in 1866 of a mathematical formula stating that light waves were only a limited portion of a large series of waves of widely different lengths and all of electromagnetic origin. He also stated that it is possible to create electromagnetic waves and that there are other waves that would be found some day. In 1896, Herz produced the waves that Maxwell predicted. These were called Herzian Waves but are known today as radio waves.

"Radio waves are, like light waves, electromagnetic waves. There are only two kinds of electromagnetic waves. Other kinds are infrared waves, ultraviolet waves and x rays. The longest waves are the radio waves, the shortest are x rays with visible light waves in between. These differ in wavelength and frequency but are alike in velocity, namely, 186,000 miles per second. When they are arranged in order as radio, infrared, visible light, ultraviolet and x rays, they are spoken of as the electromagnetic spectrum.

"The relationship between wavelength, frequency, and velocity may be explained very simply. Waves are the result of vibrations. Each vibration produces a wave. Frequency is the number of vibrations per second or the number of waves per second. It may be found mathematically by dividing the velocity (186,000 miles per second) by the length of the wave. To state this relationship in another way frequency multiplied by wavelength equals velocity. Wavelength therefore, is inversely proportional to frequency. The longest waves have the lowest frequency as radio waves

may be 1/4 to 1 1/2 miles long and vibrate at a frequency of 54,000 cycles per second (540 kilocycles) to 1,600,000 cycles per second (1600 kilocycles.)

"One of the great discoveries of the war was radar. These fit into the electromagnetic spectrum between radio waves and infrared waves, being storter than the usual radio waves and longer than infrared. Because these waves are shorter than radio waves, they require a higher frequency to produce them as 10,000,000 cycles per second. This is called ultra-high-frequency. Because they are shorter than radio waves, they are called microwaves or radar waves.

These microwaves or radar waves have characteristics similar to light waves. They can be reflected. They travel in straight lines. To send a telephone message by radar from New York to Boston, a series of relays must be set up a distance of 27 miles apart. Sound waves also consist of vibrations but a different kind of vibration, not electromagnetic. However, the characteristics of sound waves can be imparted to radar waves. These radar waves are sent out into space by a vacuum tube of ultra high frequency. They are picked up at the relay stations and amplified and sent out again. Finally, they reach Boston and are picked up by a receiver which reproduces the sound waves entering the original transmitter.

"Mr. Blasius then performed several demonstrations to show how these microwaves behave.

"Music from a victrola was transmitted by a radar wave across the room and reproduced by a loud speaker.

"The hand, being a good conductor, can stop the passage of radar waves while paper and wood cannot (radar waves pass through them). Aluminum foil stopped the passage of radar (microwaves) by reflecting them. These waves will bounce back from all good conductors of electricity.

"Microwaves will pass through a metal grill when the bars are held in a vertical position but will not pass through when the bars are in a horizontal position. This proves that these waves are polarized, that is, they travel in parallel lines. If the bars are parallel to the waves, they pass through. If the bars are perpendicular to the waves, they will be stopped.

"Just as light can be bent around a corner, inside a bar of Lucite, microwaves can be bent around a corner through a rectangular metal pipe or wire guide. Not only were these waves passed through a metal guide around a corner, but also were made to make a complete revolution, that is 'loop the loop.'"

This completed the formal talk and was followed by a question and answer period.

Question: What happens when these waves run into rain and fog?

Answer: They can pass right through rain, fog, and storms. Radar microwaves are used to discover large banks of wet air.

Question: How do you measure distance from a reflected surface?

Answer: Since these waves can travel at a speed of 186,000 miles per second, you wait for the echo and calculate the distance from the time elapsed. Because these distances and times require minute fractions of a second, a new unit of time is in use, the microsecond, a millionth of a second.

Question: Can you give us a mental picture of what an electromagnetic wave is?

Answer: Think of a row of erect dominoes. If you knock the first one down, it will throw the next one down and so on until all have been thrown down.

Question: Will an electromagnetic wave pass through a vacuum?

Answer: Yes.

Question: Do these different waves differ in wavelength and frequency?

Answer: They differ in everything except velocity.

Question: Why can't we convert large bands into smaller bands so that there will be enough room for many television bands?

Answer: This might be done some day.

Question: How do you explain why Celotex is sound proof? Does this have anything to do with these waves?

Answer: No, sound waves are different form electromagnetic waves.

WILLIAM LANDES, *Recording Secretary*

Western New York Group

Seated left to right: J. D. Converse, Canadian Industries, Ltd., speaker at Western New York Group Meeting, May 11; R. G. Macdonald, Secretary, TAPPI. Standing: J. S. Reichert, du Pont, Chairman, Western New York Group

The Western New York Group met at the Prospect House, Niagara Falls, N. Y., on May 11. J. S. Reichert of E. I. duPont de Nemours, Inc., presided as Chairman.

Following officers of the group were elected: *Chairman:* J. S. Reichert, *Vice-President:* Irving V. Earle, the Upson Co., Lockport, N. Y., *Secretary:* J. A. Barath, duPont, Niagara Falls and *Treasurer:* G. K. Storin, Niagara Alkali Co. The following committees were appointed: *Attendance:* F. B. Pickett, Kimberly-Clark Corp., and R. D. Rusch, International Paper Co.; *Arrangements:* G. K. Storin, Niagara Alkali Co., and Caleb S. Taft, International Paper Co.; *Membership:* G. E. Norton, George Irish Paper Co., and Arthur Hayes, International Paper Co., *Program:* B. S. Staneslow, Moore Forms, Inc., and G. H. Rand, International Paper Co.; and *Publicity:* J. J. Forsyth, International Paper Co., and James Walker, Hooker Electrochemical Co.

R. G. Macdonald, Secretary of TAPPI, New York, N. Y., was introduced by R. D. Rusch and gave a talk on a number of Association activities and plans.

J. D. Converse, Developments Manager of Canadian Industries, Ltd., Montreal, P. Q., talked on "Fire and Brimstone." In this talk he reviewed the history of the use of sulphur in industry and discussed a number of efforts that have been made to make the Canadian industry less dependent on foreign sources of supply for sulphur. He reported on a recent three-months trial by the Abitibi Power and Paper Co., Fort William, Ont., mill in which liquefied sulphur dioxide, made by the International Nickel Co., was used to manufacture sulphite pulp. The results were satisfactory but the run ended when the accumulated supply of sulphur dioxide ran out.

Delaware Valley

Testing Methods Panel

A panel meeting was held by the Delaware Valley Section on April 28 at the Engineer's Club in Philadelphia. During the business session preceding the meeting, E. J. Albert, Chairman of the Tellers' Committee reported on the results of the election of officers for the Delaware Valley Section during the coming season of 1949–50. These officers are the following: *Chairman:* John P. Weidner, Container Corporation of America, Manayunk, Pa.; *1st Vice-Chairman:* A. S. Erspamer, P. H. Glatfelter Co., Spring Grove, Pa.; *2nd Vice-Chairman:* James J. Eberl, Scott Paper Co., Chester, Pa.; *Secretary-Treasurer:* Miss L. V. Hans, Hercules Powder Co., Wilmington, Del.; *Executive Committee:* John Macadam, National Vulcanized Fibre Co., Yorklyn, Del.; and W. Allan Schenck, Riegel Paper Corp., Milford, N. J.

A summary of the replies received from the recent questionnaire sent to the section members was distributed to those attending the meeting. The questions included with the replies were given to the moderator of the panel who, in turn divided these questions among the other members of the panel for answering. The panel members included the following men: Ralph J. Knoll, Technical Director, Scott Paper Co., Moderator; Lewis S. Reid, Asst. Purchasing Agent of Metropolitan Life Insurance Co., also past chairman of ASTM Committee D-6; Milton Zucker, International Printing Ink Division of Interchemical Corp., New York, N. Y.; P. C. Evanoff, Mead Corp., Philadelphia, Pa.; Arthur J. Haug, Quality Control Engineer, Scott Paper Co.; and Mr. Whistler, Quality Control Engineer, P. H. Glatfelter Co.

Question: We test our papers front, middle, and back for every physical test and reel for reel. Is this sufficient, or are we really carrying the testing to extremes?

Mr. Whistler: This is definitely too much for all tests. There is no necessity for checking brightness and some of the other properties that many times. This is not too many tests for bulk or weight. However, the customer must be satisfied and whatever he considers most important must be set up for considerable more checking than other properties considered less important. We must decide how well the machine can hold the specification and the amount of testing is determined by this factor. Machine speed and type paper or length of runs also may govern the amount of testing required to maintain specifications. This is a very difficult question to answer because it is too broad and there are so many variables or conditions that must be met.

Question: What is the significance of the wax pick test insofar as printing qualities (fuzz build up on blanket or type) are concerned? On testing paper for pick we have observed individual fibers and small fiber clumps adhering to the wax sticks as low as 2 and yet according to TAPPI Standard T459-48 the pick value on the sheet was 20. Which would have the greatest influence on fuzz build up, these fibers and small clumps or those pulled off the sheet at the TAPPI endpoint?

Mr. Zucker: It isn't the paper that will not print at all that troubles us, it is the stuff that comes off easily from paper that does print that causes the build up of fuzz on the plates and causes trouble in the middle of the run.

Question: What values do you consider most important in testing the pulps you purchase and how are these correlated with machine performance and the quality of the finished sheet? And is there a quick method for determining the strength a pulp will develop?

Mr. Haug: The purpose for which a pulp is intended determines the most important values to be considered in the pulp, and what type of refining is necessary. Laboratory

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beater tests with standard hand sheet tests give the most reliable indication of a pulp's characteristics.

Question: Pinholes in paper—has TAPPI or ASTM done anything about setting up a method for testing for them?

Mr. Reid: We can place this on our agenda for consideration.

Question: In purchasing pulp, what qualities are most important?

Mr. Evanoff: That depends on the type of paper to be produced and what type of processing machinery is available.

Question: What success has been realized in determining the behavior of paper and paperboard surfaces with gloss ink, other than by use of the proof press?

Mr. Zucker: None, we have tried all sorts of tests but they cannot be correlated.

Question: What degree of agreement exists between test data assembled by the machine crews (caliper, weight, and /or other tests such as sizing) and results determined later by the technical staff on the same run of product?

Mr. Whistler: The agreement wasn't so good a number of years ago, but it has improved over the past several years. I can say that agreement does exist, due to an educational program and the machine crews recognizing the value of obtaining just and accurate information.

Question: Is there a quick, reliable method to test for fiber length?

Mr. Reid: No, you must measure by the standard method to get an accurate measurement of fiber length, although a great deal of practice may develop a judgment of fiber length which may be approximately correct.

Question: How frequently do you check process control work?

Mr. Evanoff: In bleaching, we check every batch or load. In the beater room we check every beater load for color and pH. Other testing depends on the grade and how consistently the machine is running at the time in keeping up the required standards.

Question: Does the freeness test provide a satisfactory means of controlling stock preparation for the paper machine or is there some other observation or test which would give better results?

Mr. Haug: The freeness test will give you a rapid picture of the degree of beating of pulp. It can be obtained in different ways and may give a false picture of the characteristics of the pulp on the basis of the freeness test alone. If you are making the same grade of paper continuously and are using the same type of pulp, then the freeness test is a very reliable index of the degree of beating. But if pulps from entirely different sources and types are used, then other tests might be more important, such as fiber fractionation.

Question: How do you test formation and how do you draw a line for rejection for poor formation?

Mr. Whistler: Comparison with standard samples is used in grading for formation. I wouldn't know just where the line is drawn for rejection—perhaps as long as the paper does not have any holes and the production manager will take a chance on it.

Mr. Zucker: Formation is very important because poor formation will give considerable trouble on the press.

Mr. Haug: It is difficult to assign a number to formation. One new method uses a beam of light scanning the surface and recording breaks in the beam due to irregularities.

Mr. Evanoff: Using a standard set of samples over ground glass for comparison and get both the production and inspection departments to agree on the comparisons has proved quite satisfactory.

Question: Should the TAPPI standard method for counting dirt be changed?

Mr. Evanoff: We have found the Clark method reasonably satisfactory in making speck analysis.

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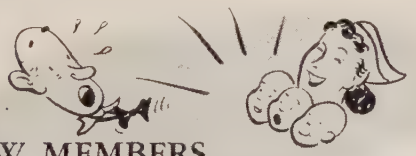

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(continued from page 67A)

Mr. Haug: I believe that the charts should be changed. I would suggest that the Canadian instrument using electrical measurement of dirt is more objective.

Question: Is the discussion on the erasure test settled by TAPPI and ASTM?

Mr. Reid: It took a long time before we finally found a machine which would reproduce results satisfactorily before we could adopt it as a tentative standard.

Question: What is the significance of smoothness, gloss, and/or glare as related to printing properties?

Mr. Zucker: Gloss has no relation to printing. That is a property that is very little understood and does not mean a thing in relation to printing in itself, but may be measure of smoothness. However, smoothness is important for letter press printing, but not so important in printing offset, or from rubber plates or by the gravure process. It is a combination of smoothness and compressibility that is important from the printing standpoint.

Question: How do you calibrate a Mullen tester?

Mr. Reid: Calibrate the gage by direct weights and use metal foil prepared for the purpose for checking, also by comparison tests on the same sheet with other laboratories.

Question: Slime and pitch are two important production problems—how do you control them?

Mr. Evanoff: Some mercury and phenol compounds work quite well in controlling slime. We test for pitch in the pulp before buying, and if we feel there is enough to cause trouble, we don't buy it.

Less than half of the questions submitted were brought up at the meeting, but since the time was getting late, the meeting was adjourned.

Lois V. Hans, *Secretary*

Ohio

New Officers for the 1949–50 season of the Ohio Section of TAPPI were elected at the annual meeting, held at the Hotel Manchester Middletown, Ohio on Thursday April 21, 1949. Members of the Miami Valley Division of the Superintendents Association were guests of the Ohio Section. The new officers and executive committee members are as follows: *Chairman:* Arthur Thurn, Champion Paper & Fibre Co. Hamilton, Ohio; *Vice-Chairman:* Don J. Goodman, Sorg Paper Co. Middletown, Ohio; *Recording Secretary:* Earl Knapp, Weston Mfg. Co. Dayton, Ohio; *Corresponding Sec.:* John L. Clouse, Oxford Miami Paper Co., West Carrollton, Ohio; and *Treasurer:* R. D. McCarron, Stein, Hall Co., Inc. Cincinnati 2, Ohio.

Executive Committee: Phil S. Cade, Harding-Jones Paper Co., Middletown, Ohio; Carl Roess, Wrenn Paper Co., Middletown, Ohio; D. M. Yost, Sorg Paper Co., Middletown, Ohio; E. C. Hendrickson, The Mead Corp., Chillicothe, Ohio; and C. E. Brandon, Aetna Paper Co., Dayton 7, Ohio.

The attendance at the Ohio Section meetings this year averaged 108 as compared with 89 at the seven meetings held last year.

Phil S. Cade, retiring chairman of the Ohio Section presided at the meeting. Kon Matchuk, Vice-Chairman of the Miami Valley Division of the Superintendents Association extended greetings to the group. K. P. Geohegan, Vice-President of National TAPPI was introduced and asked to speak. Mr. Geohegan expressed the desire of National TAPPI to work closely with the various Sections and stressed the hope that more individual TAPPI members will participate in the association, both sectionally and nationally.

The evening program was attended by 170 members and guests. Following the short business meeting, the group was entertained with a well balanced program of song, dance and novelty numbers arranged by a theatrical agency of Cincinnati.

Herbert A. Smith, *Recording Secretary*

Kalamazoo Valley

The Kalamazoo Valley Section will hold its annual golf outing at the Gull Lake Country Club, on June 28. The committee in charge of arrangements is John Verdon, American Cyanamid Co., F. Van Streain, Price & Pierce Ltd., and D. Knight, Bulkley, Dunton Co.

New England

Building Sales Through Market Research

Building sales through market research and quality control was the theme of the last meeting of the 1948–49 program of the New England Section which was held at the Weldon Hotel, Greenfield, Massachusetts on May 13, 1949. The first speaker, R. F. Hurst, Assistant to the Vice-President in charge of Manufacturing, Bigelow Sanford Carpet Co., was introduced by A. G. Dries, Hercules Powder Co., who with Miss H. U. Kiely of the American Writing Paper Co., was co-chairman of the program committee.

Mr. Hurst, introducing his subject, mentioned that his company, the largest producers of carpeting, was over 100 years old and that they have built up their reputation on quality products. The rug business is highly competitive with their financial earnings being greatly affected by the amount of imperfect goods which must be sold at a discount. After taking into consideration the fact that about a third of the company's total personnel in the three plants had been employed by them two years or less, a program was developed to make all employees aware of the importance of quality, that job security was based on the company's competitive position, and that every worker was important to the company. Also included in the program were efforts to improve workmanship and plant efficiency and to foster an appreciation of the functions of the quality control department. To be effective it was realized that all levels within the company had to be reached.

The basic premise upon which the program was based was in the fact that a satisfied customer has good will toward the product and that advertising is a constant reminder to that customer of the company and the product. Naturally, a dissatisfied purchaser is, to the opposite degree, similarly reminded. Therefore, to obtain full value from advertising efforts, the product must have quality.

It was expected that with product quality improvements, savings to almost two million dollars yearly could be effected in reductions in inspection, supervision, rework, scrap, waste, materials handling, etc. At this point it might be mentioned that Mr. Hurst stated in the discussion following the presentation of the paper, that although their program is but a third completed, about $1,400,000 saving has been realized and that it is expected that the figure may be double at the end. The cost was estimated as being about $30,000.

The initial step was obtaining opinions from all the company departments and then an introductory letter was written by the vice-president in charge of manufacturing to all foremen indicating the need for quality. This was followed by a quality improvement contest for only the foremen. Later a suggestion contest was held in which the nonsupervisory employees could take part. Publicity on the program was contained in the house magazine, posters, displays. Emphasis was given to the extent of the National advertising program which stressed quality and to customer complaints. A news letter to the executives and minor executives also featured the latter. Department performance records and reports of scrap and waste were posted in all departments. A film was made featuring an animated symbol, John Q. Quality, to show right and wrong techniques; also incorporated were shots of those employers who

were performance leaders in the various departments showing them at work. This film with a comprehensive display was shown at a conference which was attended by all supervisory employees and their reactions and suggestions solicited. At the same conference, discussion groups were formed, at line level, to discuss the program and general departmental efficiency. Mr. Hurst said that they received enough worth-while suggestions from these meetings to warrant setting up a $2^1/_2$-year schedule for their adoption.

The film is now being shown to all the employees on company time, to salesmen, and to the dealers. It is believed that considerable advances are being made in improving employer-employee relations and other intangibles difficult to evaluate in addition to promoting quality in the mill and an appreciation of it by their sales force.

The talk was illustrated by numerous slides illustrating the copy and angles used in promoting the program. Discussion was limited because of lack of time; however, one point that Mr. Hurst brought out is that employees must be acquainted with the fact that in addition to meeting competition in the same line, their company's product must also compete with other wholly unrelated items. In their case, the housewife will consider in terms of value and desire, painting, papering, a new refrigerator, or radio that she may have instead of a new rug. Therefore, the employee must realize that his company, to stay in business, must market a quality product at its fair value, and that he, along with his fellow workers, is the important factor in the meeting of these requirements. This efficiency and workmanship are directly responsible for the product his company manufactures.

The meeting was adjourned and resumed at the dinner which was attended by about 80 persons. Chester H. Child, of the Merrimac Paper Co., was toastmaster and introduced A. E. Bachmann, Missisquoi Corp., the President of the Technical Association.

The Nominating Committee announced a slate of officers for 1949–50 which was elected unanimously. Philip S. Bolton, Robert Gair Co., is the *Chairman*, R. J. Proctor, Fitchburg Paper Co., *Vice-Chairman*, A. G. Dries, Hercules Powder Co., *Secretary*, and H. T. Barker, Bird- & Son, *Treasurer*. The following were named to the *Executive Committee:* Miss H. U. Kiely, American Writing Paper Co., P. Gooding, Strathmore Paper Co., C. F. Young, Rising Paper Co., R. H. Mosher, Holyoke Card & Paper Co., G. L. Benson, St. Regis Paper Co., and E. W. Strecker, Esleeck Mfg. Co.

The first speaker on the evening program was Philip Proctor of Johns-Manville who spoke briefly before showing a film which his company produced to acquaint their employees with the functions of quality control so that they would appreciate its assistance in production problems. While not theoretical, it is an excellent primer in the statistical approach used in quality control. Since the picture was made for the education of their own employees, the examples were taken from the problems in the manufacture of J-M products. It was stressed that it is not necessary to become involved in intricate mathematics but rather that only an understanding of the charted results is essential to the production man. In this regard, it was pointed out that the charts would not show cause but only deviation from the normal probability, in which case either a beneficial or detrimental effect was taking place in the process and so should be investigated immediately

In discussing the film, Mr. Proctor indicated that while it might be difficult to apply quality control to a process and sometimes considerable time was required before it was possible to interpret the data, the end results usually justified the expenditure and effort required in its development.

R. S. Aries of R. S. Aries & Associates gave the final talk "Market Research as an Aid to Sales" which directed attention to the possibilities of the technical man in the field of market research. First and foremost the engineer must be more sales minded and better informed on general economic conditions rather than just interested in his immediate production problems. He must realize that his company must secure more of an economic benefit out of his services than the amount of his salary and that he does have a position where he can be of more value to his company if he will apply himself.

Among the trends which he should watch are such items as population growth, age trends, area developments, the quality and price of his company's competitors' products, and the profit differentials of the products in which he is interested. If past records show that the company is making a product, even though the market is assured, that does not yield a satisfactory return, that item should be dropped in favor of one in the line that does have, or an entirely new product produced. The mere satisfaction of a customer using a marginal item does not warrant its continued manufacture. Following this particular line of thought, Mr. Aries expressed the opinion that the small mill has an advantage in that it can be much more flexible than a large producer.

New product development, in which the advice of the sales department is essential, is a field for the engineer. However, any efforts to make a new item in a particular mill that follows a product already advertised as being on the market, are relatively worthless and especially so if the field is limited.

Finally it should be realized that meeting the present is the immediate problem regardless of the more or less bright prospects of the future. If the present is neglected, there may be no future for the company.

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

William B. Alexander, Field Engineer, Bakelite Corporation, Philadelphia, Pa., a 1941 graduate of Princeton University.

James R. Almand, General Superintendent, Paper Div., Brown Company, Berlin, N. H. Attended Louisiana College.

Bruce Armstrong, Engineer, Jackson & Church, Saginaw, Mich., a 1916 graduate of Columbia University with an E.M. degree.

Dan P. Ashton, Chemical Engineer, Crown Zellerbach Corp., West Linn, Ore., a 1947 graduate of Oregon State College.

Ernest F. Barker, Chemist, Blake, Moffitt & Towne, San Francisco, Calif., Attended the University of California.

Matthew B. Barkley, President, Southern Corporation, Charleston, S. C., a 1928 graduate of Yale University.

Norman J. M. Bennett, Manager, Bridgend Paper Mills Co. Ltd., London, England, a 1940 graduate of Cambridge University.

Talbot F. Bennett, Jr., Chemist, Reynolds Metals Co., Bellwood Plant, Richmond, Va., a 1948 graduate of the University of Georgia.

Maurice Beren, Vice-President, Pyrotex Leather Co., Leominster, Mass., a 1928 graduate of Massachusetts Institute of Technology.

Julius F. T. Berliner, Chemical and Engineering Consultant, Chicago, Ill., a 1926 graduate of George Washington University with a Ph.D. degree.

George F. Blasius, Technical Director, Burgess Pigment Co., Paterson, N. J., a 1933 graduate of Brooklyn Polytechnic Institute.

Samuel M. Bratton, Technical Adviser, The Pusey & Jones Corp., Wilmington, Del.

Martin O. Braunohler, Engineer, Keuffel & Esser Co., Hoboken, N. J.

Stephen W. Clark, Laboratory Technician, News Syndicate Co., New York, N. Y. Attended Norwich University and the College of the City of New York.

Thomas J. A. Crozier, Chemist, Southern Advance Bag & Paper Co., Hodge, La., a 1937 graduate of the University of Maine.

Robert C. Dale, Chemical Engineer, Mid-States Gummed Paper Co., Chicago, Ill., a 1941 graduate of the University of Illinois.

James H. Dutruc, Draftman, Black-Clawson Co., Hamilton, Ohio, a graduate of the University of Besancon, France.

David L. Emerson, Assistant Engineer, Rhode Island Cardboard Co., Pawtucket., R. I., a 1945 graduate of Harvard College.

Clarence E. Felt, Leader, Packaging Section, General Mills, Inc., Minneapolis, Minn., a 1933 graduate of the University of Minnesota.

Thomas E. Flanagan, Chemist, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich., a 1948 graduate of New York State College of Forestry.

Ray W. Foster, Electrical Engineer, Champion Paper & Fibre Co., Canton, N. C., a 1934 graduate of the University of North Carolina.

L. V. Frisch, Mill Manager, Fir-Tex Insulating Board Co., St. Helens, Ore., a 1936 graduate of the University of Idaho with an M.S. degree.

Sylvester D. Frost, Master Mechanic, Macon Kraft Co., Macon, Ga.

Karl-Folke Gothner, Chemist, Camp Manufacturing Co., Franklin, Va., a 1946 graduate of Stockholm Technical Institute.

Peter S. Greenwood, Jr., Assistant Forester, West Tacoma Newsprint Co., a 1946 graduate of the University of Washington.

Robert L. Griffeth, Director of Technical Dept., Mica Insulator Co., Schenectady, N. Y., a 1934 graduate of Union College, Schenectady.

Howard M. Hall, Salesman, Marble-Nye Co., Worcester, Mass., a 1930 graduate of Brown University.

Kenneth D. Hay, Chief Chemist, Peter J. Schweitzer, Inc., Spotswood, N. J., a 1941 graduate of the Institute of Paper Chemistry with a Ph.D. degree.

Raymond A. Hill, Jr., Engineer, Congoleum-Nairn, Inc., Cedarhurst, Md., a 1943 graduate of Villanova College.

Gaston L. Hollimon, General Foreman, Pulp Mill, Longview Fibre Co., Longview, Wash., a 1941 graduate of the University of Alabama.

K. M. Paul Hsi, Graduate Student, University of Maine, Orono, Me., a 1941 graduate of the University of Nanking, China.

Randolph N. Jacobson, Development Engineer, Kimberly-Clark Corp., Kimberly, Wis., a 1938 graduate of Northwestern University.

Raymond M. Janz, Senior Chemical Engineer, Crown Zellerbach Corp., West Linn, Ore., a 1935 graduate of Oregon State College.

Leslie Justice, Superintendent, Paper Mill, Fort Orange Paper Co., Castleton-on-Hudson, N. Y.

Harry K. Linzell, Engineer, United States Wallboard Machinery Co., New York, N. Y., a 1921 graduate of Ohio State University.

Alex J. Malaschevitz, Chief Chemist, Catalin Corp. of America, Fords, N. J., a 1933 graduate of Rutgers University.

Alex J. Nagy, Jr., Chemical Engineer, New York & Pennsylvania Co., Lock Haven, Pa., a 1948 graduate of Pennsylvania State College.

August G. Oberland, Sales Engineer, Samuel M. Langston Co., Chicago, Ill.

Siebert J. Oettinger, Sales Engineer, Artisan Metal Products, Inc., Waltham, Mass., a 1939 graduate of Massachusetts Institute of Technology.

Lawrence O'Toole, Laboratory Control, Central Paper Co., Muskegon, Mich.

Norval W. Postweiler, Packaging Engineer, National Biscuit Co., New York, N. Y., a 1934 graduate of Northwestern University.

Herbert F. Rance, Manager of Research and Development, Wiggins Teape Group Research Headquarters, Stoneywood Works, Bucksburn, Aberdeenshire, Scotland, a 1931 graduate of Imperial College of Science and Technology with a Ph.D. degree.

Ramuhalli N. Rao, Paper Technologist, Bangalore City, India, a 1933 graduate of Intermediate College, Bangalore.

William J. Rice, Chemical Engineer, Central States Paper & Bag Co., Inc., St. Louis, Mo. Attended Washington University.

Seymour Robb, Librarian, Virginia Polytechnic Institute, Blacksburg, Va.

Julia Saunders, Librarian, Enoch Pratt Free Library, Baltimore, Md.

Roger J. Shouvlin, Laboratory Supervisor, The Bauer Bros. Co., Springfield, Ohio, a 1941 graduate of the University of Notre Dame.

Thaxter W. Small, Jr., Sales Engineer, Sprout, Waldron & Co., Muncy, Pa., a 1934 graduate of the University of Maine.

James O. Starkweather, Engineer, Hollingsworth & Whitney Co., Winslow, Me., a 1944 graduate of Brown University with an M.S. degree from Massachusetts Institute of Technology in 1948.

Walter O. Stevens, Consulting Engineer, W. O. Stevens & Co., Seattle, Wash., a 1925 graduate of McGill University.

Ray A. Thompson, Sales Engineer, Samuel M. Langston Co., Camden, N. J., a 1941 graduate of the University of New Mexico.

L. G. Vande Bogart, Research Engineer, Crane Co., Chicago, Ill. Attended Lawrence College, Valparaiso University and the University of Chicago.

Robert T. Van Derveer, Student, New York State College of Forestry, Syracuse, N. Y.

Arto Vesanto, Assistant Mill Manager, Enso-Gutzeit OY, Vuoksenniska, Kaukopaa, Finland, a 1944 graduate of the Technical University of Helsinki.

Laurence T. Waterman, Assistant to Superintendent, St. Regis Paper Co., Tacoma, Wash., a 1937 graduate of the New York State College of Forestry.

Robert H. Wright, Head, Div. of Chemistry, British Columbia Research Council, University of British Columbia, Vancouver, B. C., Canada, a 1931 graduate of McGill University with a Ph.D. degree.

Ferdinand Wultsch, Technical Manager, Bruder Kranz Papierfabriken A. G., Graz, Andritz, Austria, a 1937 graduate of Technical Hochschule, Darmstadt with a Dr. Ing. degree.

TAPPI Notes

Carl J. Bergendahl, formerly superintendent of Inlands A/B, Lilla Edet, Sweden, is now sales engineer for Pagel-Horton Co., New York, N. Y.

Francis O. Boylon, formerly of the Fernstrom Paper Mills, is now tissue mill superintendent, Crown Zellerbach Corp., Camas, Wash.

C. H. Butterfield, engineer, formerly of Dayton, Ohio, is now sales engineer, Bagley & Sewall Co., Watertown, N. Y.

Warren J. Current, formerly division engineer, Champion Paper & Fibre Co., is now with the San Joaquim Div., Fibreboard Products, Inc., Antioch, Calif.

Claude H. Fletcher, formerly of Time, Inc., is now with the Corn Products Sales Co., Kalamazoo, Mich.

James E. Foote, formerly with the B-F-D Div., Diamond Match Co., is now with E. B. Eddy Co., Hull, P. Q.

G. Emil Haeger, formerly student New York State College of Forestry is now general superintendent, Inlands A/B., Lilla Edet, Sweden.

Joseph C. Harkness, formerly of the Johns-Manville Corp., is now plant manager, The Flintkote Co., Mt. Carmel, Ill.

James D. Griffin, formerly of the Scutan Div. Union Bag & Paper Corp., is now President, Specialty Converters, E. Braintree, Mass.

Emil Heuser, formerly of Downey, Calif., is now located at 339 Vista De La Playa, La Jolla, Calif.

Donald K. MacBain, formerly of the B-F-D Div., Diamond Match Co., is now chemical engineer, Tork-Master Co., Long Beach, Calif.

David E. MacKnight, formerly with Industrias Cavallari, Inc., is now superintendent and technical adviser, Companhia Nacional de Papel, Lapa, Sao Paulo, Brazil.

Robert T. Mashburn, formerly chief chemist, Hercules Powder Co., Kalamazoo, Mich., has been transferred to Wilmington, Del., as research supervisor.

Philip W. Oppenheimer, formerly of Heyden Chemical Co., is now in the textile sales for Brand & Oppenheimer, New York, N. Y.

Richard Osborn, formerly with the St. Regis Paper Co., is now technical director, Finch, Pruyn Co., Glens Falls, N. Y.

Noel R. Phillips, formerly research chemist of Hollingsworth & Whitney, is with Champion Paper & Fibre Co., Canton, N. C.

Richard A. Premo is now control supervisor, Gould Paper Co., Div., Continental Can Co., Lyons Falls, N. Y.

Milton R. Roberts is now chief chemist, Hudson Pulp & Paper Co., Palatka, Fla.

Martin M. Scher, formerly student of the University of Maine, is now engineer for the Ashland Paper Mills, Inc., New York, N. Y.

George C. Schmid, formerly chief chemist, Cellutin Corp., is now with the Starbuck Mfg. Co., Leeds, Mass.

R. E. Sheffer is now asst. works manager, Aluminum Co. of America, New Kensington, Pa.

Lloyd D. Smiley, formerly of the Gahagan Construction Co., is now in the Paper Industry Div., Grundler Pulverizer Co., 2915 N. Market St., St. Louis 6, Mo.

Wayne D. Stephenson, formerly of the Riegel Paper Co., is now technical director, D. M. Bare Paper Co., Roaring Spring, Pa.

Victor J. Wirpsa, formerly of the Champion Paper & Fibre Co., is now in specialty sales, Printing, Publication & Converting Div., St. Regis Paper Corp., Kalamazoo, Mich.

S. W. Yates, formerly of the Gardner-Richardson Co., is now Asst. to the Vice-President in charge of Production, National Folding Box Co., New Haven, Conn.

The name of the Gardner-Richardson Co., has been changed to the Gardner Board & Carton Co., Middletown, Ohio.

C. N. Hagar, Jr., has succeeded James E. Foote as official corporate representative of the B-F-D Div., Diamond Match Co., in the Technical Association.

J. L. De Tar has succeeded Allen E. Sutton as the official representative of the Downingtown Mfg. Co., in the Association.

The new address of Rust Engineering Co., is the Rust Bldg., 575 Sixth Ave., Pittsburgh 19, Pa.

Recent visitors from abroad include:

Carrado Nadari, Director, S. P. A. La Fibra Vulcanizzata e Cartiere Prealpine, Milan, Italy.

Hans Fahlstrom, engineer, Katrinefors Paper Mills, Ltd., Katrinefors, Sweden.

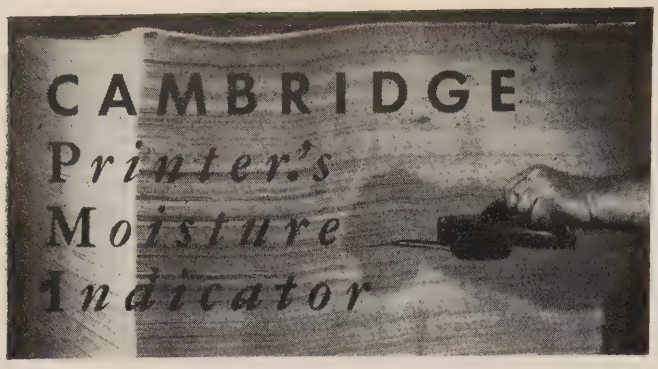
Albert Marsoni and Natalina Sabadina, respectively, manager and engineer, Cartiers F. A. Marsoni, glassine paper makers, Venice, Italy.

Leonard Job and Chris. Myburgh, respectively, asst. manager and chemical plant superintendent, South African Pulp and Paper Industries, Ltd., Enstra, South Africa.

Karl Zappert, technical director, Ind. Klabin do Parana de Cellulose, Parana, Brazil.

The following companies have recently become sustaining members of the Technical Association:

Union Screen Plate Co. of Canada, Lenoxville, P. Q.
Holyoke Machine Co., Holyoke, Mass.
Morden Machines Co., Portland, Ore.
National Starch Products Co., New York, N. Y.
Paper Mill News, New York, N. Y.
Niagara Alkali Co., New York, N. Y.
J. M. Huber Co., New York, N. Y.
Chain Belt Co., Milwaukee, Wis.
The Sinclair Co., Holyoke, Mass.
Ethyl Corp., New York, N. Y.
W. A. Cleary Co., New Brunswick, N. J.
Myers, Fuller & Addington, New York, N. Y.



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OBITUARIES

Lewis B. Miller

Lewis B. Miller, Chairman of the TAPPI Water Committee died on April 29th. Dr. Miller died suddenly at his home in Cincinnati, when he appeared to be well along the road to recovery, following a stroke several months ago.

He was born in Parkersburg, Iowa, on June 24, 1896, and graduated from the Iowa State University, receiving his Ph.D. degree from Columbia University in 1922. From 1923–25 he was research chemist for the U. S. Public Health Service. From 1925–30 he was a chemical engineer for the Universal Portland Cement Co. in Chicago. He was a research engineer for the Johns-Manville Corp., New York, N. Y., from 1930–35, with the Ruberoid Co., Erie, Pa., from 1935–38, Keasbey and Mattison, Ambler, Pa., from 1938–42 when he joined W. H. & L. D. Betz, consulting water chemists. In 1946 he became Professor of Chemical Engineering at the University of Cincinnati.

Dr. Miller was one of the leaders in the field of water technology and did much for TAPPI and the pulp and paper industry as Chairman of the Water Committee. His publications appeared in a number of books and technical magazines. He was responsible for the preparation of TAPPI Monograph No. 1, Industrial Water for Pulp, Paper and Paperboard Manufacture. He was undertaking the preparation of a sequel to this monograph at the time of his death. He is survived by his wife Elsie Cutler Miller; son Lt. George L. Miller, now stationed with the 4th constabulary as acting Captain in Austria; and sister Mrs. E. G. Kothe of Parkersburg, Iowa.

Erik Solitander

Erik Solitander died in Helsinki, on January 30th, at the age of 39. He was assistant director of the Finnish Board Mills Association. He was born in Tammerfors, Finland, on October 1, 1909, and graduated from the Technical University of Finland in 1932, and worked for two years at the Walkiakoski Paper Mill. From 1935–39 he was technical expert for the Jay Madden Corporation in New York City, specializing chiefly on paperboard. In 1939 he returned to Finland where he became sales manager for the Finnish Woodpulp Union. In 1943 he joined the Finnish Board Mills Association as assistant director.

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Calendar of TAPPI Meetings

NATIONAL

General Fall Meeting, Multnomah Hotel, Portland, Ore., September 11–15, 1949.

Fourth Engineering Conference of the Pulp and Paper Industry, Statler Hotel, Boston, Mass., October 31, November 1–3, 1949.

***Yes*—Go West!**

***Then*—Go East!**

RECENT BOOKS

The following books are reviewed primarily for the purpose of acquainting readers of *Tappi* with sources of information that can be of value in their daily work. Copies of any of these books can most conveniently be obtained through the Technical Association of the Pulp and Paper Industry, 122 East 42nd Street, New York 17, N. Y.

Handbook of Plastics. By Herbert R. Simonds, Consulting Engineer, Archie J. Weith, former Director Research and Development, Bakelite Corp., and M. H. Bigelow, Director of Technical Service, Plaskon Div., Libby-Owens-Ford Glass Co., 2nd Ed. D. Van Nostrand Co., New York, 1949. Cloth $6^1/_2 \times 8^3/_4$, 1511 pages. Illustrated. $25.

The increase in basic information concerning the rapidly expanding plastics industry can be readily noted by the contrast in size of the second edition with the first which appeared in 1943. Moreover, the changes that have taken place in this period of six years practically required the authors to prepare an entirely new book. An interesting aspect of this volume is the evidence of wide authoritative cooperation by the manufacturers who are given several opportunities to report in detail on their own products. An exceptionally strong advisory committee lends considerable prestige to the work.

It is difficult to review adequately this book since each chapter merits consideration. It is, as its title implies, a reference handbook and seems to fully conform to this classification since almost any question on the subject that may be asked can be answered with the help of its excellent index.

Some of the chapter titles will give a reasonable idea of its coverage: survey of the industry, properties, commercial materials, primary ingredients, textile fibers, rubber, natural resins, laminates and films, coatings, adhesives, manufacturing processes, plant equipment, chemistry and analytical methods, cost accounting, patents, useful tables, trade-names, glossary, and bibliography.

Copies may be obtained through the Book Dept., Technical Assoc. Pulp and Paper Industry, 122 E. 42nd Street, New York 17, N. Y.

Encyclopedia of Chemical Technology. Edited by Raymond E. Kirk and Donald F. Othmer, Polytechnic Institute of Brooklyn. Vol. 2. The Interscience Encyclopedia, Inc., New York. 1948. Cloth, $7^1/_4 \times 10^1/_2$, 915 pages. Illustrated. $20.

This review must be made with the understanding that the volume referred to is not for sale by itself. It is one of ten volumes which must be subscribed for in their entirety. Two to three volumes are to be published each year.

As indicated, it is an encyclopedia to which a large number of individuals have made contributions. It begins where Vol. 1 ended with anthrone and continues through antibiotics, antifreezes, antiseptics, asbestos, asphalt, azo dyes, bakery products, batteries, brewing, bituminous roof materials, building materials, etc., to carbon (arc).

No standard pattern is followed in treating each item but nearly all of the information that one would expect to find is there, together with cross references to various classification of these products. The caliber of the contributors, whose names are appended to the contributed items creates confidence in the value of the work.

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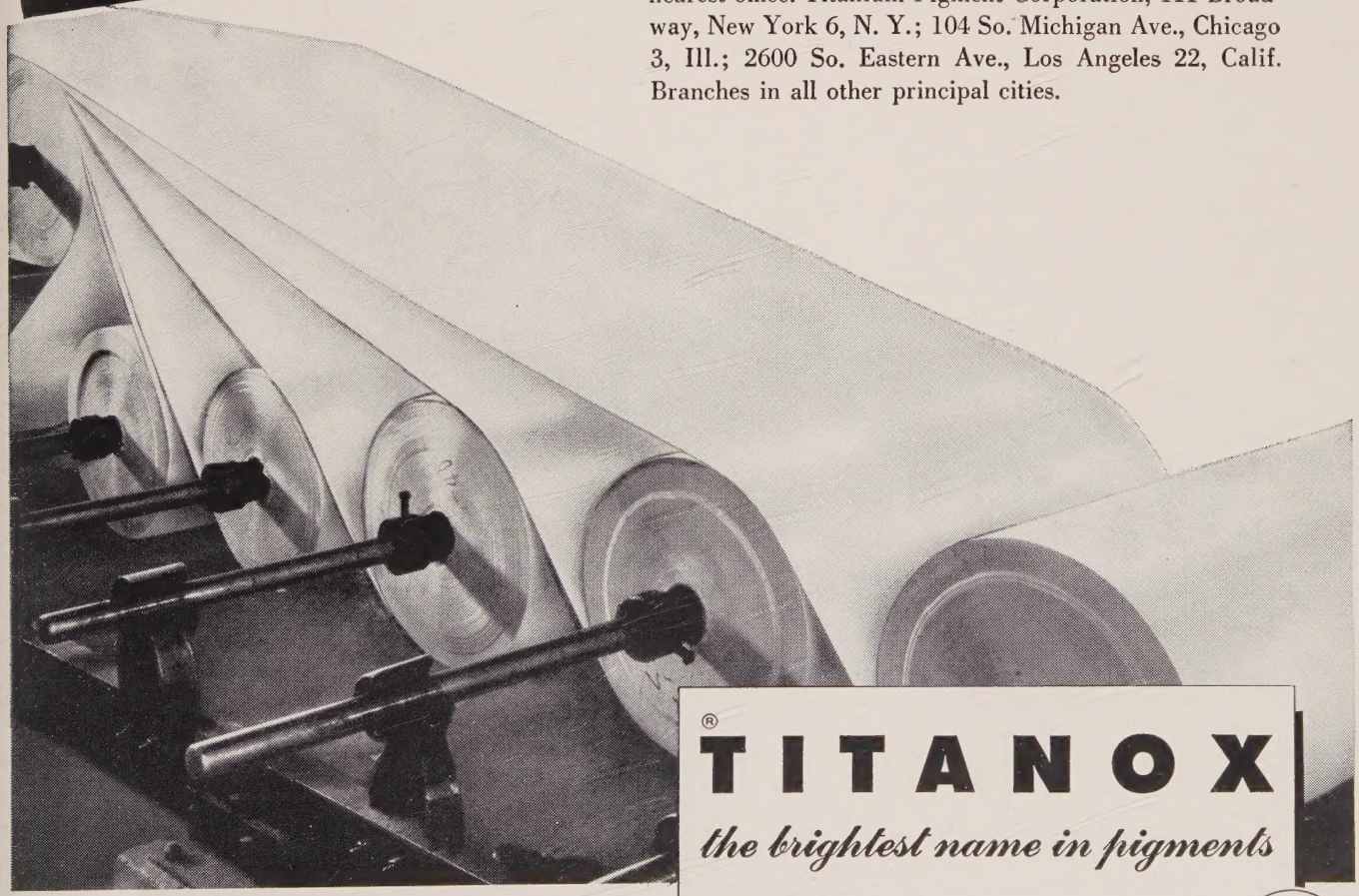

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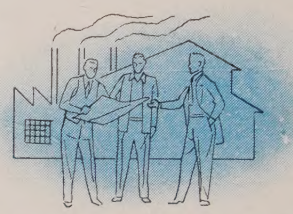

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